Enhancing antenatal care decisions among expectant mothers in Uganda

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Enhancing Antenatal Care Decisions among Expectant Mothers in Uganda

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by

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To Ryan, Rasha and Rand

Preface and Acknowledgement

My motivation to undertake this research was instigated by the fact that I am a mother of three and I live in Sub-Saharan Africa that has been hard-hit by the worst maternal mortality rates, contributing to 56 percent of the global maternal deaths. My aspirations of being a change agent took the better part of me to start on this academic journey. As an engaged scholar, this research started off by exploring different cases aimed at understanding the challenges that expectant mothers face during antenatal care, the conditions that inhibit their decisions to seek care and the environment within which they operate. From this, it was discovered that expectant mothers operate in a multi-stakeholder environment whose decisions largely depended on many actors in the antenatal care cycle. This was followed by the design of the antenatal care studio which was underpinned on the principles of decision enhancement of Keen and Sol (2008). The ACS design was instantiated and evaluated with expectant mothers and other stakeholders (midwives, CHW's and peers) to ascertain usage, usability and usefulness. The ACS is a contribution to theory and practice and I am hopeful that it can create change in the maternal health sector.

All this wouldn't have been possible without the divine involvement of the almighty Allah (Most Gracious, Most Merciful and All Knowing). My childhood dream was to one day get to the peak of the academic ladder but how to get there always bewildered me. The trust I bestowed in the Almighty and the constant break-throughs He offered me at times when this whole journey seemed blurry and impossible to complete, is a true manifestation that I was under His divine mercy and guardianship.

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Appreciation goes out to my second promoter Prof.dr. Jude.T.Lubega who has not given up on me even when I had given up on myself. It is because of you that I started this research journey

and it's because of your valuable and constructive suggestions that I have successfully reached the final destination of this research. I consider it an honour to have worked with you and will surely continue working with you.

Special thanks to the University of Groningen for this academic sponsorship that, I might have never gotten hadn't it been Prof. Henk's input and willingness to guide me in this research. I also wish to thank the management of Faculty of Economics and Business at the University of Groningen specifically Arthur de Boer, Linda Henriquez, Irene Ravenhorst for the continuous support that you offered me while at Groningen.

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Special thanks to my aunt, Sarah Kasujja who put the first brick on my academic journey and constantly believed and loved me unconditionally. Also, to my late aunt Fiona Pink Naluwooza who was my support system in everything that I did and never relented but continuously encouraged me and saw the best in me. May you continue to RIP.

Along this journey, many academic scholars guided me but special thanks goes out to Dr. Agnes Nakakawa who was the very first person to read, encourage and guide me into research. Others include Dr. Mercy Amiyo, Dr. Drake Mirembe. Also, I have not been alone in this journey, I have worked with other research fellows whom we shared ideas and insights. I share credit of my work with Robert Tweheyo, Pearl Tumwebaze, Peace Tumuheki, Irene Arinaitwe and Zubeda.

This thesis would have remained a dream had it not been for the expectant mothers who agreed to work with me from the start of this research journey up to the end. Notably, I extend my appreciation to the community health workers, peers, research assistants and lastly my programmer Nerjer Najib who constantly changed the studio every time the studio requirements changed. Your brilliant ideas that you brought to the table coupled with those long hours of work will never be forgotten. Thank you!

I consider it an honour to have known and stayed with Henk Valk while in Groningen. Thank you for being kind to me and offering me shelter and taking me around Groningen. I specifically thank you for teaching me how to *ride a bicycle* in my adult age. You made my stay quite simple and adaptive.

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Lastly, to my family that constantly believed in me, encouraged me especially during those low moments. You never left my side, you walked with me right from the beginning till the end. Thank you so much. And to my children who tested the bitter pill of my absentia at such a tender age, I will forever be indebted to you.

This PhD has been the most rewarding experience in my whole entire academic trajectory

Praise be to Allah

Most Gracious, Most Merciful

Hasifah Kasujja Namatovu

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CHAPTER 1 – ABOUT ANTENATAL CARE

This chapter introduces an overview of maternal health focusing on antenatal care as a constituent of maternal health. The chapter has the following outline; section 1.1 discusses challenges facing antenatal care in Uganda, section 1.2 highlights the problem statement, section 1.3 lists the research questions and section 1.4 discusses the research approach.

1.1 Antenatal Care Perspectives

Maternal mortality remains a very big challenge in Sub-Saharan Africa including Uganda. According to WHO (2016a), 830 women die every day from preventable causes related to pregnancy and childbirth, that is more than 30 women per hour. Out of these deaths, eighty-five per cent occurred in Sub-Saharan African and South Asia. Sub-Saharan Africa alone accounts for 56 per cent of global maternal deaths (WHO, 2012b). In Uganda alone, an estimated 16 women die from giving birth every day. On average, that is one death every hour and a half and nearly 6,000 every year (Nassaka, 2016; MoFED, 2012; MoFED, 2010). Uganda lays in the Sub-Sahara region with a maternal mortality rate of 438 deaths per 100,000 in 2011 (MoFPED, 2015).

The direct causes of maternal deaths include haemorrhage (27%), sepsis (11%), unsafe abortions (8%), pre-eclampsia (14%) and obstructed labour (9%) contributing 75 to 80 per cent of deaths (WHO, 2015a; MoH, 2013; MoFED, 2010), while the indirect causes contribute 20 to 25 per cent of maternal deaths and these include HIV/AIDS, malaria, anaemia, malnutrition, hepatitis and diabetes (Nieburg, 2012; UNICEF, 2009). It should be noted that these conditions are preventable and research shows that 80 percent of these deaths can be averted should women have access to essential maternity and basic health services (UNICEF, 2009).

WHO (2012a) reports maternal mortality to be higher in women living in rural areas and among poorer communities. The high maternal deaths in resource-poor countries have been attributed to poverty at family and community level, lack of access to modern family planning, low community level awareness of danger signs of pregnancy/labour (WHO, 2015b; Nieburg, 2012). Furthermore, the unwillingness or inability of some pregnant women to attend antenatal care or deliver in a health facility with the assistance of a skilled birth attendant and weak health systems such as emergency transport gaps, facility location among others has aggravated the situation (WHO, 2013; Nieburg, 2012; Human Development Report, 2011).

Many of these deaths can be avoided once mothers get adequate maternal access and emergency obstetric care (WHO, 2015a). The most critical intervention of maternal mortality as described by (WHO, 2016; WHO, 2015b; Atekyereza and Mubiru, 2014; WHO 2007) includes i) participation in antenatal care, ii) delivery by skilled birth attendant, iii) access to EmOC, and iv) access to family planning services.

Improving maternal health was Millenium Development Goal five (MDG 5), now Sustainable Development Goal three (SDG 3), which aims at improving reproductive, maternal and child health (United Nations, 2016). Antenatal care coverage is target B of MDG 5, which focuses on the universal access to reproductive health (WHO, 2015a). WHO recommends at least four visits during pregnancy, where in each visit, women should be provided with nutritional advice, alerted on warning signs and given support when planning a safe delivery (MDG, 2016).

Coverage levels in Sub-Saharan Africa have remained still for the past two decades, with a slight improvement (from 47-49 percent) in the number of women receiving the recommended care (MDG, 2016).

1.2 Antenatal Care in Uganda

Antenatal care (ANC) is done to prepare a pregnant women for birth and motherhood as well as prevent, detect, alleviate, or manage the three types of health problems during pregnancy that affect mothers and babies (WHO, 2016b; WHO, 2007; Lincetto et al. n.d). These health problems include; i) complication of pregnancy itself, ii) pre-existing conditions that worsen during pregnancy, iii) effects of unhealthy life style. Some of the antenatal care services offered include tetanus toxoid administration, blood pressure screening, nutritional advice and supplements (iron, vitamins, micronutrients), preparation of birth preparedness plan including preparing for emergencies, access to bed nets and intermittent preventive therapy in pregnancy (for malaria), screening for HIV and other STI's, diagnosis and treatment of UTI's (Cumber et al. 2016; Nieburg, 2012).

It should be noted that ANC provides women with appropriate information and advice for a healthy pregnancy, safe childbirth and postnatal recovery. It also directly improves the survival and health of babies, indirectly saves the lives of mothers and babies by promoting good health before and after child birth; and informs women about danger signs and symptoms (WHO & UNICEF, 2002; Lincetto, et al. n.d).

ANC establishes the first contact with the health facilities and it is highly premised that mothers who have attended at least more than one ANC are likely to give birth with a help of a skilled birth attendant (Guliani, Sepehri & Serieux, 2012). Further, ANC also provides an avenue for mothers to receive information about HIV prevention (Nieburg, 2012). The health condition of a mother during pregnancy is ever-changing, dynamic and uncertain. This requires quick decision making among women which is highly hinged on the information obtained during ANC. During ANC, women access information about danger signs, nutrition, preeclampsia which are key ingredients in enhancing decision making. However, inadequate care during pregnancy poses a lot of risk both to the mother and her unborn baby

Table 1-1: Universal Access to Antenatal Care in Uganda. (Source: Uganda Demographic Health Survey, 2011)

1. Antenatal Care Coverage	1995	2000/01	2006	2011
1.1 at least one visit by skilled provider	91.3%	92.4%	93.5%	94.9%
1.2 at least four visits by any provider	47.2%	41.9%	47.2%	47.6%

1.3 Challenges Facing Antenatal Care in Uganda

Inadequate funding of the sector

The prioritization of the productive over the consumptive sector has partly caused the underfunding of the health sector in favour of development of roads, infrastructure and the energy sector (Larsen, 2014; MoFPED, 2014). Insufficient funding is a major hindrance to the full implementation of policies for safe motherhood. Uganda has not abided by the Abuja Declaration to assign 15 percent of national budgets to health care (Kagumire, 2010) and the Ministry of Health falls short of finances to deliver maternal health services. The underinvestment in the health sector has largely contributed to the country's shortage of medical staff, lack of medical supplies and essential medicines among others (Larsen, 2014; Parliament, 2012; Wallace, 2012). These conditions make it very hard for medical practitioners to ensure appropriate care when women arrive in health facilities for checkups and deliveries.

Social, Cultural and Political Barriers

It is well documented that a range of social, cultural, and political barriers also exclude women from the formal health care system (Thaddeus and Maine, 1994; Gabrysch and Campbell, 2009). Regarding maternal health service provision, studies find that "the majority of pregnant women attend antenatal check-ups at health facilities, but difficulties in physical access

compounded by cultural restrictions mean women's use of health facilities for delivery is limited in Uganda" (MacKian, 2008).

Inadequate Information

Information is an important resource in a complex and ever changing environment like antenatal care. WHO (2015b) cited the lack of information as a major source of problem among pregnant women in Uganda. Information is a vital resource to individuals who according to (WHO, 2008) seek information for various reasons ranging from mere curiosity, self-diagnosis, analysis, evaluation and treatment for health. The kind of information that pregnant women need ranges from antenatal care, EmOC, nutrition, identifying and managing preeclampsia, danger signs (Sarah, et al. 2013; WHO, 2008) among others. The amount of information and authority that pregnant women have for decision making is key (Sundari, 1992). The quality of decisions made largely depend upon the type of information made available to a user (Sarah, et al. 2013). The lack of information/knowledge may mean that a pregnant woman is unaware of the severity of their own condition which increases their risk to maternal death (Oxaal and Baden, 1996).

Absence of comprehensive EMOC equipment.

The absence of emergency obstetric care (EMOC) equipment in health facilities inhibit provision of EMOC services leading to the death of mothers (MoFPED, 2014). The lack of EMOC limits the mother's ability to access lifesaving services in times of an emergency which is exacerbated by the lack of information about the few health facilities that offer these services (MoFPED, 2014; MoFED, 2010).

HIV/AIDS in childbearing mothers

Higher levels of HIV/AIDS in childbearing population coupled with ineffective use of antenatal services that can prevent and detect problems related to HIV/AIDS has posed a significant challenge (WHO, 2012a) to expectant mothers.

Lack of ambulances in local governments

A number of local governments lack ambulatory services to handle referrals (MoFPED, 2014). This means that mothers are not referred to the next level of health care leaving many in prolonged labor which sometimes leads to their demise or that of their babies.

Regulated but unsupervised environment

There is a large number of unqualified practitioners including traditional herbalists, spiritual leaders, homeopathic healers, and non-qualified practitioners who purport to practice biomedicine (Justin et al. 2004). These individual private providers are small-scale enterprises with limited capacity, negligible interaction with the public sector and with little regulation (Justin et al. 2004). However, because of the so many challenges like distance, lack of money to go to hospitals, poor services in hospitals, many expectant mothers especially in the rural setting are left no choice but to seek care from these unqualified practitioners.

Inadequate Infrastructure

Lack of infrastructure like maternity wards in most local government hospitals has impaired the delivery of maternal health services (MoFPED, 2014a). While some hospitals have functional wards, many lack functional theatres to handle emergency obstetric care (Mbonye et al. 2007).

Inadequate utilization of antenatal services

Antenatal care (ANC) involves screening of health conditions that are likely to increase the possibility of adverse pregnancy outcomes and providing therapeutic intervention known to be effective and educating pregnant women about safe birth, emergencies during pregnancy and how to deal with them (Kawungezi et al. 2015; WHO, 2002a). However, it has been noted that over 90% of pregnant women attend at least one antenatal and only 48% attend the recommended four visits (Demographic Health Survey, 2011; UNICEF, 2012). As put by Kawungezi et al (2015), the rural women in Uganda are twice likely not to attend ANC than their urban counterparts. ANC provides an avenue to detect risky health conditions and refer them for early management leading to better maternal outcomes (WHO, 2012c; Magadi, Madise & Diamond, 2001). ANC therefore leads to the improvement of maternal health conditions by constantly monitoring a mother's health of any danger likely to be experienced during pregnancy.

1.4 Problem Statement

It should be noted that a paltry 48% of expectant mothers attend the recommended four antenatal care visits (WHO, 2015a; Kawungezi et al. 2015; WHO, 2013; Kabakyenga et al. 2011) a figure way below the WHO recommendation of every pregnant woman receiving quality care throughout her pregnancy. The challenges discussed in section 1.3 have

contributed to the low attendance of antenatal care yet this is the entry point to the provision of integrated care and thus an avenue for expectant mothers to engage with medical experts and other stakeholders. Despite various approaches put in place by the Ministry of Health and other development agencies to strengthen and empower women to seek care (WHO, 2016; MoFPED, 2015b; MoH, 2014), mother's ability to make decisions to seek care comes with a lot of challenges as discussed in section 2.2.

Having integrated approaches and systems to enhance decision making among pregnant women could improve pregnancy outcomes, yet little is known about these approaches currently in Uganda. Decision enhancement is known for improving decision making by focusing on decisions that matter thereby bringing together different stakeholders in a facilitative, engaging and interactive environment to deliberate on key decision issues (Keen and Sol, 2008). Hence, the proposition is that using decision enhancement services in enhancing antenatal care decision making challenges will improve pregnancy outcomes.

1.5 Decision Enhancement

A decision is an outcome of the interplay between problems, solutions participants and choices, all of which arrive independently and change continuously (Wang, 2008). Tryfos (2001) defines decision making as a process of coming up with the best choice from the available alternatives. Decision Enhancement (DE) is "a management lens or way to look out at the dynamic and volatile domains of complex private and public sector decision-making and, increasingly, their interdependencies and necessary collaborations" (Keen and Sol, 2008). DE aims at enhancing decision making processes through professional practices that fuse human skills and technology; bringing together the best of executive judgment and experience with the best computer modelling, information management and analytic methods while facilitating scenario building and evaluation, collaboration and simulation to rehearse the future as illustrated in the fig. 1-2 (Keen and Sol, 2008).

Use of DE services as posited by Keen and Sol (2008) is adopted to help enhance the decision making practices by not only providing information to expectant mothers but provide a virtual environment where different actors engage and exchange ideas simultaneously. In the decision enhancement environment, services are offered by the three interwoven entities i.e. people, technology and processes (Keen and Sol, 2008) as shown in fig. 1-1 and these entities cannot work independently in a decision enhancement environment. Decision making processes are

comprised of activities that people are tasked to do, however, for *people* to function proficiently in a DE environment, they need *technology* to be able to efficiently execute all the activities in a given *process*. So a blend of the three is very significant for the functioning of the DE environment. Decision enhancement focuses on "decisions that matter" that are known to be uncertain, ill-structured and volatile in nature. In relation to this research, decision enhancement was adopted because the antenatal care domain is characterised by unstable requirements, the critical dependence on team work to produce effective decisions and there exists a complex interaction between expectant mothers, CHW and midwives.

Decision enhancement is a space embodied in studios. Studios are either physical environments such as meeting rooms in which participants and expert facilitators come together or virtual environments in which decision enhancement services are for instance deployed via the internet (DeSanctis & Gallupe, 1987; Johansen, 1988). A studio is an environment or shared space or forum designed around a process or processes, that contain a set of integrated tools/technologies that enable stakeholders (people) to interactively collaborate to generate and analyse possible solutions to a given problem (Keen and Sol, 2008; Muniafu, 2007).

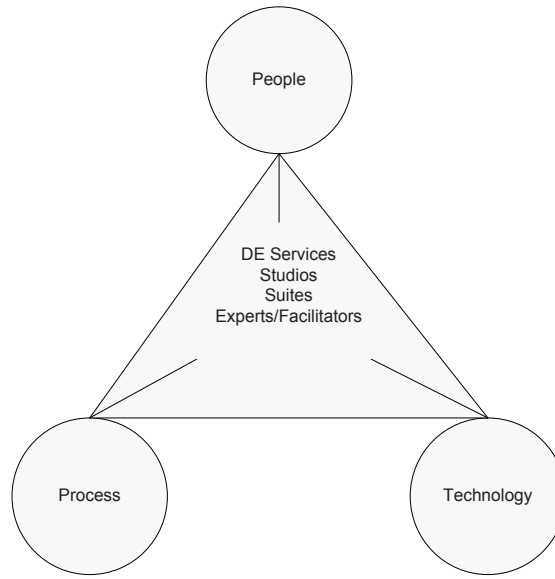

Figure 1-1: Decision Enhancement: The blend of people, process and technology through studios (Keen and Sol, 2008)

Studios and suites that are targeted to make decisions that matter comprise of services to the people that make the decisions but not a technical product as is with decision support systems

(Keen and Sol, 2008). DE focuses on services rather than systems that is, studios and suites target all levels of decision making, DE services enhance the link between people and technology and lastly, DE offers practical ways for technical professionals to move their services from useful, to usable to used (Keen and Sol, 2008).

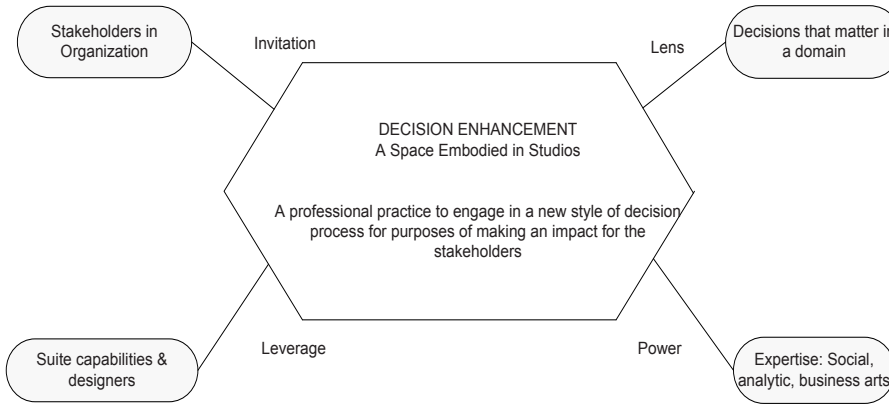

Figure 1-2: Decision Enhancement – A field of Practice (Keen and Sol, 2008)

Noting that antenatal care decisions of expectant mothers involves the input of different stakeholders, this necessitates a shared environment where ideas can be exchanged. One common aspect about a studio is that "*it's a shared space*" that can accommodate different actors and it provides a platform to answer the *"what-if"* questions (Keen and Sol, 2008) which are typical in the antenatal care domain. Several researchers (Tumwebaze, 2016; Mirembe, 2015; Aregu, 2014; Amiyo; 2012) in East Africa have successfully applied decision enhancement and it is against this background that we propose a decision enhancement approach to enhance antenatal care decision practices of expectant mothers in Uganda.

1.6 Research Questions

Decision making among expectant mothers is still a major challenge in Uganda with more than half of the population of expectant mothers incapable of making decisions to seek care. Therefore, this research seeks to answer the following questions.

Main Research Question

How can antenatal care decisions among expectant mothers in Uganda be enhanced?

Sub Questions

1. What antenatal care challenges do expectant mothers face in Uganda?
2. What factors influence expectant mothers' decisions to utilize antenatal care in Uganda?
3. How can a design leading to a studio be achieved?
4. How can a decision enhancement studio be instantiated to improve antenatal care decisions among expectant mothers in Uganda?
5. How can a decision enhancement studio be effectively evaluated for perceived usefulness and usability?

1.7 Research Approach

A research approach is defined as a way of going about one's research, which may embody a particular style and employ different methods or techniques (Galliers, 1992). This entails philosophies, methodology and strategies, instruments and tools used throughout the research. Choosing a research methodology requires a deeper understanding than practicalities

Research Philosophy

This research adopted design science (Hevner and Chatterjee, 2010) as a stance of engaged scholarship (Van de Ven, 2007). The choice of using these paradigms is based on the fact that they address challenges within the information systems discipline in a novel and constructive way (Mathieson and Nielsen, 2008) and also address the gap between theory and practice, a dichotomy that seeks to extend the theoretical boundaries by creating new and purposeful artefacts.

Van de Ven (2007) defines engaged scholarship as "a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems." It is a form of inquiry where researchers involve others and leverage their different perspective to learn about a problem domain (Van de Ven, 2007). The choice of using engaged scholarship in this research leaned towards the

need for creating a practical solution to address antenatal care decision making challenges facing pregnant women in Uganda. Engaged scholarship requires meeting and talking with the people who experience and know the problem (Van de Ven, 2007). In relation to this study, we engaged expectant mothers, midwives, Community Health Workers (CWHs) and peer mother with the purpose of identifying real issues.

Design science is defined by Hevner and Chatterjee (2010) as "a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artefacts". This paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artefacts and with a high priority on relevance in the application domain, which is the foundation of this research. Design science exemplar seeks to create innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, management, and use of information systems can be effectively and efficiently accomplished (Denning, 1997; Tsichritzis, 1998).

Antenatal care is a complex domain with no straightforward approach to addressing the challenges therein but, the adoption of design science as an exemplar is considered (Rittel and Webber 1984; Brooks 1987) to be the appropriate approach to addressing wicked problems. The nature and complexity of antenatal care problems is characterised by i) unstable requirements which can be explained by the ill-defined nature of the maternal health environment, ii) the complex interaction that exists among the stakeholders, and iii) the critical dependence on teamwork to produce efficient and effective solutions. Such problems can be effectively addressed using design science (Hevner et al, 2004), which attempts to adopt the creativeness of people to design and implement innovative artefacts that are useful to pregnant women, thereby offering an effective means of addressing the relevance gap.

Design science research is embodied by epistemological alternatives which try to address the imbalance between relevance and rigor. Positivism, interpretivism and pragmatism are available for social science research (Gonzalez & Sol, 2012). This research however adopts interpretivism and pragmatism influenced by the ontological underpinning of critical realism. With critical realism, our world of experience is a social construction that does not exist independently of the observer's conceptual frame of reference (Johnson & Duberley, 2003; Weick, 1989). Critical realist believe that there is a real world out there and our understanding of it is very limited, hence knowing a complex reality demands use of multiple perspectives

(Van de Ven, 2007). The major application of critical realism in research is explaining the complex social events (Lyubimov, 2015).

Positivism assumes that "the truth is out there" and that it can be reached through the methods of science (Wynn, 2001). It claims that the social world can be described by law-like generalizations stemming from collection of value-free facts (Chen & Hirschheim, 2004). Remenyi et al. (1998) looks at positivism as "working with an observable social reality and that the end product of such research can be law-like generalization" utilizing a hypothetico-deductive process (Easterby-Smith et al. 2002).

Gonzalez & Sol (2012) argue that it would be hard to associate design science research in information systems (DSRIS) with positivism as a whole, given that theoretically it excludes the researcher influence from the research process. Yet, the design science approach must of necessity include the researcher/ designer as a reflective practitioner.

Interpretivism argues that both the researcher and the human actors in the phenomenon under study interpret the situation (Nandhakumar & Jones, 1997). Interpretivism is an epistemology that advocates that it is necessary for a researcher to understand differences between humans in our roles as social actors. Interpretive research is identified with the presence of participant's perspectives as primary sources of information analysed against cultural and contextual circumstances (Klein & Myers, 1999). Interpretive approaches are subjective aiming at understanding the information systems context and the way in which actors draw on and interpret elements of context (Mitev, 2000). In the social world it is argued that individuals and groups make sense of situations based upon their individual experience, memories and expectations (Flowers, 2009). Meaning therefore is constructed and over time constantly re-constructed through experience resulting in many differing interpretations. In relation to this study, case studies which involved in-depth interviews, a qualitative approach aimed at understanding and explaining the problem in its contextual setting were explored.

Pragmatism places the weight of truth on the consequences of beliefs, where beliefs are progressively attained, for instance, through the method of science (Pierce, 1992). This stems from the understanding that our beliefs guide our desires and shape our actions (Gonzalez & Sol, 2012). "To a pragmatist, the mandate of science is not to find the truth or reality, the existence of which are perpetually in dispute, but to facilitate human problem-solving" (Powell, 2001, p.884). Pragmatists start off with a research question to determine their research framework (Wahyuni, 2012).

Tashakkori & Teddlie (1998) suggest that it is more appropriate for the researcher in a particular study to think of the philosophy adopted as a continuum rather than opposite positions. They note that "at some point the knower and the known must be interactive, while at others, one may more easily stand apart from what one is studying." They further contend that pragmatism is intuitively appealing, largely because it avoids the researcher engaging in what they see as rather pointless debates about such concepts as truth and reality. Hughes and Sharrock (1997) argue that "applying methods that suit the problem" is the best approach when dealing with certain problems. Pragmatism employs both qualitative and quantitative methods useful in triangulating results (Patton 1980; Brannick and Roche 1997). Gill and Johnson (1997) perceive that multi-method methodology leads to convergent validation of research results.

Research Strategy

According to Saunders et al. (2009) a research strategy is "a general plan of how the researcher goes about answering the research questions". This study adopted the abductive approach using the singerian inquiry system. Adopting the singerian inquiry draws from the fact that its goal seeking and idealistic (Churchman, 1971). The goal is the creation of common knowledge, suitable for social and public problems. Secondly, antenatal care challenges are social problems residing within the community that is exceedingly complex and highly interdependent. Because of the interdependency and interconnectedness of social problems, pragmatists advocate for a holistic approach to studying these problems. Thirdly, the singerian approach takes on a practical view of solving a problem which involves using any means available. Fourthly, it brings in ethical concerns and emphasis on practical knowledge (Courtney, Chae & Hall, 2000), which is important for the pragmatist nature of this research.

Abductive reasoning yields the kind of decision making that does its best with the information at hand which often is incomplete. Abductive reasoning is "backwards" reasoning starting from the known facts and probe backwards into the reasons or explanation for these facts (Walton, 2001). As put by Aliseda (2007) "abduction is reasoning from an observation to its possible explanation" which borrows a philosophical position of pragmatism. Pragmatists may employ abductive reasoning in solving complex problems like antenatal care problems that do not have a clear-cut path to their solution. This study employs Sol's (1982) strategy of abductive reasoning explained in five phases of *initiation, abstraction, theory formulation, instantiation and evaluation* shown in figure 3.

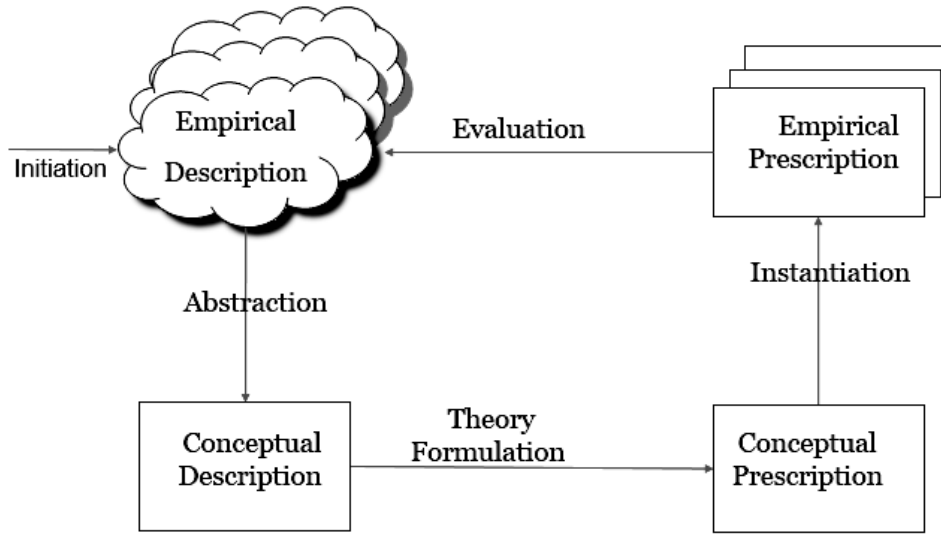

Figure 1-3: Strategy of Abductive Reasoning (Sol, 1982)

This strategy allows multiple cases to be explored in order to better understand the problem domain, a principle emphasized in design science and engaged scholarship. This strategy is used for ill-defined problems characterized by: 1) inductive reasoning moving from exploration and understanding to design, 2) an interdisciplinary approach, 3) enabling the generation of alternatives for problem solving in an iterative design process and 4) interdependent analysis and synthesis activities (Gonzalez & Sol, 2008).

Initiation: This study was concerned with addressing antenatal care decision making challenges among expectant mothers in Uganda. This phase begun by reviewing literature in order to ascertain the existing problems in antenatal care. This was followed by a preliminary study to explore cases to validate findings in literature and conceptualize the problem. The output of this stage was an empirical description with a clearly defined problem scope.

Abstraction: This phase involved an in-depth survey of the identified cases to gain a generic understanding of the problems pregnant women face during antenatal care in Uganda. Different approaches were used such as structured and unstructured interviews, focus group discussions with pregnant women, and questionnaires were later analysed to try and establish any correlations that could give further explanation on the behaviour of certain variables. These were done to try and get insight on the challenges pregnant women face during decision making, the types of decisions and the decision processes involved, the factors that influence

decisions and the degree to which they do. The output of this phase was a conceptual description

Theory Formulation: The target of theory building was to formulate an appropriate solution to the conceptualised problem (Aregu, 2014) using the available yet scanty information, which guided the process of creating the antenatal care studio design. Through interaction with expectant mothers and other stakeholders during focus group discussions, detailed specifications for the components of the design, which formed the output of this phase were realised. Sol's "ways-of" framework (1988) offered a description into a new way of thinking, working, modelling and governance of the ACS design.

Instantiation: The design from the theory formulation phase becomes a key input in this phase. The purpose of this phase therefore was to implement the antenatal care studio design, hence the empirical prescription became the output from this phase. In essence, empirical prescription is putting the conceptual prescription in practice (Van de Kar, 2004), which in the context of this research was achieved through the Antenatal Care Studio for expectant mothers packaged with suites of services and guidelines.

Evaluation: This process involved a rigorous testing of the Antenatal Care Studio in order to verify and validate that the solution addresses the needs of expectant mothers in Uganda. The Antenatal Care Studio was tested with expectant mothers, midwives, peers and CHW's for usability, usefulness and usage. For quantitative and qualitative evaluation, focus group discussions and questionnaires were used respectively to ascertain that the studio enhances antenatal care decisions of expectant mothers in Uganda.

Thesis Outline

This thesis is structured in seven chapters as highlighted below.

Chapter 1 which gives a synopsis into the research domain gives a detailed description of antenatal care issues facing expectant mothers in Uganda. From this, the research problem and research questions were framed which was followed by the research approach. The research approach provided systematic steps that were used to guide the research process.

Chapter 2 provided an in-depth insight into literature surrounding antenatal care and decision making. Important to note were the theoretical perspectives that were discussed that helped in the grounding of this research. This was concluded with the discussion of the possible application of decision enhancement in antenatal care.

Chapter 3 discussed the exploration study that was conducted in Jinja and Kampala to validate what was documented in literature and ascertain issues surrounding antenatal care decision making practices among expectant mothers in Uganda. Case studies and focus group discussions which were aided by questionnaires and structured interviews offered the researcher an opportunity to understand the real problems at hand. From the data analysed, a generic understanding into the issues affecting expectant mothers across Uganda were conceptualised.

In Chapter 4, the ideas from chapter three offered a key ingredient into the design of the antenatal care studio (ACS). Consultations back and forth were made with different stakeholders, and after a few iterations, the final design was realised. This was expressed using Sol's "ways of" framework which offers a logical sequence into the description of the design.

Chapter 5 discussed the instantiation of the ACS design which was majorly comprised of five suites namely; the emergency suite, the engagement suite, the self-care suite, the training suite and the messaging suite. All these suites were embedded with services and recipes guiding their use. The instantiation was both mobile and web based.

Chapter 6 reported on the evaluation process which was aimed at assessing whether the antenatal care studio met the purpose for which it was instantiated. The ACS was evaluated against usefulness, usability and usage with the different stakeholders namely, expectant mothers, CHW, midwives and peer mothers. The techniques used in the evaluation process included practical experimentations and case study demonstration in a naturalistic environment.

Chapter 7 gave an overall reflection of the research schema discussing research questions and how they were addresses, research contribution, possible generalizability of this research and the directions for future research.

CHAPTER 2 – LITERATURE REVIEW

In this chapter, literature pertaining to antenatal care was reviewed together with theories grounding this research. This chapter is presented in six sections; section 2.1 discusses reasons why antenatal care is important; section 2.2 highlights factors that influence decisions to utilize antenatal care services; section 2.3 looks at antenatal care services; section 2.4 discusses the theoretical perspectives grounding this research; section 2.5 looks at the mhealth application in antenatal care and 2.6 concludes the chapter by looking at decision enhancement and antenatal care.

2.1 Why Antenatal Care

Antenatal care has proved to be important to the lives of the expectant mothers and those of their unborn babies despite the fact that it is still not well attended in Uganda. Several scholars postulate why pregnant women should attend ANC, and the reasons include:

- Antenatal is a source for micronutrient supplementation, treatment for pregnancy induced hypertension to prevent preeclampsia and eclampsia (Cumber et al. 2016).
- ANC represents an important entry point for different programmes and provision of integrated care. Pregnancy often represents the first opportunity for a woman to establish contact with the health system (Steegers, 2015; Lincetto, et al. n.d).
- ANC visits provide opportunities to promote lasting health, offering benefits that continue beyond the pregnancy period. This includes birth preparedness, but also extends to cover health information and counselling for pregnant women, their families, and communities (Cumber et al. 2016).
- ANC offers an opportunity to develop a birth and emergency preparedness plan. WHO recommends that all pregnant women have a written plan for dealing with birth and any unexpected adverse events, such as complications or emergencies that may occur during pregnancy or childbirth (Cumber et al. 2016; Lincetto, et al. n.d).
- Although antenatal services (ANC) have not proven to be very useful in predicting the occurrence of complications during pregnancy, Philip (2012), argues that ANC provides an opportunity to educate women and their families about the danger signs that sometimes occur in pregnancy and labour and about the need for a birth

preparedness plan, including planning for emergencies. ANC helps women understand warning signs during pregnancy and childbirth (Cumber et al. 2016).

- Evidence shows that ANC has considerably reduced on antepartum haemorrhage which was noted to be one of the leading direct causes of maternal death (MDG, 2015).

WHO recommends that pregnant women should attend a minimum of four ANC visits for; health promotion, assessment, prevention and treatment (WHO, 2015b). The first visit is on confirmation of pregnancy, the second visit is between 20-28 weeks, the third 34-36 weeks and the fourth is before the woman's expected date of delivery or when she feels need to consult the medical expert or health worker.

2.2 Factors That Influence the Decisions to Utilize Antenatal Care Services in Uganda

Long distances to hospital

Many pregnant women especially those in the rural setting do not attend antenatal care because the distance involved to walk to the health facility transcends the drive to go for ANC (Kenneth and Soo, 2013; Matsuoka, et al. 2010; Titaley et al. 2010). Some pregnant women determined to walk are deterred by the risks and fear of physical harm as a result of walking long distances (Kenneth and Soo, 2013; Lee, 2009) which outweighs the benefits of antenatal care. As put by Kabakyenga (2012), distance of more than one hour in travel to the health facility influences a woman's decision to seek care from a skilled attendant. Dickson et al (2013) noted that distance impacted health care knowledge among women as well as decisions to seek care.

Inability to afford the costs of seeking care

The cost of going to health facilities for antenatal care were viewed as one of the inhibiting factors influencing decision to seek antenatal care (Kenneth and Soo, 2013; Dickson et al. 2013; Matsuoka, et al. 2010) especially in the rural or hard to reach communities of Uganda. Even when antenatal care access is free, mothers cannot afford the cost of transport to and from the health facility (Matsuoka, et al. 2010; Titaley et al. 2010), paying for drugs, tests, and medical cards (Atuyambe et al. 2009). This therefore affects the decisions of many mothers from seeking care even when they wished to use the antenatal care services.

Cultural Inclinations

Some women do not attend antenatal care because of their cultural beliefs and tribal traditions surrounding the nature of pregnancy and childbirth (Ediau et al. 2013; Kyomuhendo, 2003). In

some cultures, not engaging in antenatal services was associated with a belief that pregnancy disclosure could lead to unsolicited religious or spiritual complications (Kenneth and Soo, 2013). This means that many mothers, even those with high risk pregnancies miss the opportunity of identifying the risks early enough for rectification. These cultural beliefs limited early access to antenatal care, even when a woman suspected she was pregnant, the belief surpassed the motivation to go for antenatal care (PATH, 2006; Titaley et al. 2010). Hence, the decision to seek care is largely inclined on a mother's attachment and belief in culture.

Level of Education

Studies have shown that women with low levels of education are likely not to attend antenatal care even when it is provided (Simkhada et al. 2008; Houweling et al. 2007). Women with a primary level education were more likely to attend ANC than women who could not read or write (Zeine, et al. 2010). The extent to which education impact maternal mortality is distant but as Oxaal and Baden (1996) rightly put it, education has a known effect of lowering fertility and empowering women with the ability to make decisions. The level of education is likely to influence the use of a skilled birth attendant (Kabakyenga, 2012) and as Lisa (2011) rightly put it, the more informed a mother is, the higher the chances of making decisions to seek care.

Lack of knowledge

Antenatal period provide an opportunity to supply information about danger signs, birth spacing, nutrition among others (Kawungezi et al. 2015; Sarah et al. 2013) therefore the lack of knowledge on issues pertaining to antenatal care is likely to influence a mother's decision not to seek care. Moses et al. (2012) in their study in Eastern Uganda identified gaps associated with counselling mothers on risk factor recognition and birth preparedness. In their analysis, counselling of mothers on danger signs was poorly done with many not in position to identify these danger signs. A mother with little or no knowledge on the likely risks they are bound to experience during pregnancy is more likely not to seek care. As put by Lee et al. (2009) and Lincetto et al. (n.d) the lack of knowledge about the seriousness of complications, danger signs in pregnancy or where to receive services poses great risks to mothers. Every moment of delay in seeking and receiving care during obstetric emergencies increases the risk of stillbirth, neonatal or maternal death or morbidity (Lee et al. 2009).

Role of Family, Friends and in-laws

In some cases, the decision to engage in antenatal care is made by the tribal elders, husband, mother-in-law, senior family members than the pregnant woman herself (Simkhada et al. 2010;

Matsuoka, et al. 2010, PATH, 2006; Oxaal and Baden, 1996). In some studies, it was found out that a positive attitude of the husband towards antenatal care attendance (Zeine, et al. 2010) greatly influenced women decisions to attend antenatal care services.

Poor Services Offered at Health Centres

Waiting in long queues to see the health professional coupled with the mistreatment by midwives and the lack of medical equipment inhibited mothers to go for antenatal care (Marianne, et al. 2012; Parliament of Uganda, 2012; MoH, 2011a). This is aggravated by the fact that pregnant women have to present clinic cards before being admitted during labour (Kenneth and Soo, 2013; Pamela, 2012; Mrisho et al. 2009) forcing many to attend once for the clinical card and others opting to deliver at home if they didn't obtain one. A health worker working in isolation depending on solitary resources and perspective is likely to put a patient at risk (Gawande, 2011; Grumbach & Bodenheimer, 2004).

Inadequacy of staff to handle complications

The ratio of physicians to patients in Uganda is estimated to be 5.3 per 100.000 population and the ratio of midwife to patient is 1-11.000 (Parliament of Uganda, 2012). Whereas having few skilled attendants poses great risk, whilst, having few who can attend to complications poses much more great danger to mothers. Inadequacy of skilled attendants in many health facilities has increased maternal deaths in Uganda leaving many mothers with no choice but to give birth with the help of traditional birth attendants, village elders or a family member (Simkhada et al. 2010). A survey carried out by the health ministry found out that only 57% of Ugandan hospitals are able to administer general anaesthesia (MoH, 2006). This implies that the remaining 43% can't handle emergency obstetric care which leaves a lot of mothers in a vulnerable state.

Limited Use of Technology

Despite the widespread affordability of mobile phones to even the most rural communities in Uganda (Pamela, 2012), user adoption of mobile phone technology in maternal health is still low in Uganda (Byomire & Maiga, 2015). This implies that the expectant mother's decision making ability is affected as technology eases information flow. The use of mobile and wireless technologies provides an opportunity to rapidly connect people thereby reducing on the delays across the chain of health decisions (Akter & Ray, 2010). It should be noted that mobile phone usage has become an important tool in health service delivery including maternal health

(Pamela, 2012; William, 2013) and regarded a more accessible and less expensive means of bridging the digital divide (Wade, 2004).

Delay to receive care

The delay to get service when a pregnant woman reaches a health facility is mainly attributed to, i) the shortage of labour, ii) lack of trained personnel, iii) staff incompetence and iv) lack of morale to work as a result of low and delayed salaries coupled with working longer hours (Parliament of Uganda, 2012; MoH, 2011a; Lee, 2009). The shortage of labour is heightened by the lack of systems that could support community based workers to monitor and track at-risk patients and refer those in urgent need to specialized care in a timely manner (UNICEF, 2011). These factors step in the way of a woman's will to make a decisions to seek timely care. The inability of pregnant women to recognize pregnancy-related emergencies causes delay to make decisions to seek care (Nieburg, 2012; Thaddeus and Maine, 1994) thereby exposing many mothers to continued but yet preventable maternal deaths.

Parity

It has also been observed that women with parity of more than four and those below 25 years are less likely to make decisions to attend antenatal care or seek care from a skilled attendant (Kawungezi et al. 2015; Kabakyenga, 2012). Women below 25 years fear to be ridiculed in society and therefore prefer to keep their pregnancies a secret (Zeine, et al. 2010).

Stock outs

Stock outs of essential drugs has been cited as one of the reasons for the poor turn up of antenatal care (Parliament of Uganda, 2012). This frustrates the decision to seek care when mothers feel that the much of the needed drugs will not be accessed (Ahimbisibwe, 2013; Pamela, 2012; MoH, 2006).

Lack of power to make decisions.

Most women especially the less educated and those that are financially dependent on their husbands have less autonomy to make decisions to seek care to use maternal health services (Ganley, 2015; Kyomuhendo, 2003).

From the meta-analysis of the literature reviewed, the lack of information or having little knowledge on issues pertaining to antenatal care negatively impacts the woman's ability to make decisions to seek care. As a result of not seeking care, this means that expectant mothers have limited access to antenatal care services which among others involves the early

identification and rectification of conditions that would rather be fatal if not diagnosed and treated urgently.

In rural/resource constrained settings, the community health worker serves as the initial point of contact for health in Uganda (Uganda Village Project, 2009). They are volunteers each provided with a bicycle to traverse the village they are assigned. These CHW's relay basic health information to mothers at the grass root level and directing them to the right health facilities for various levels of health care (Uganda Village Project, 2009). They conduct health education, community mobilization, sensitize women on how to detect danger signs and the importance of uptake of health services specifically antenatal care and delivery at health facilities (MoH, 2015).

They visit each homestead recording information concerning deliveries that took place in the reporting month, number of visits given by CHW to the relevant family members and number of antenatal care visits to the health centre (MoH, 2010b). Additionally, they are required to report any persons identified with danger signs during pregnancy, refer cases, those that delivered from home and any maternal death that may have occurred. All women known to be HIV positive and those sleeping under an insecticide treated mosquito net are also recorded. All this information is recorded in the register which forms part of the health management information system managed by the Ministry of Health (MoH, 2010b). This hierarchical reporting mechanism and information flow starts at the village level, through the parish (health centre), Sub-County to the district level then to the Ministry of Health and vice versa.

CHW's are registered to a health centre at a parish and they are a link between the health centre and the rural mothers. Likewise, information from the health facilities is channelled through the CHW to the mothers (Kamwesiga, 2011). The major challenge associated with CHW engagement is the lack of morale to work because the government offers little or no facilitation to the CHW's (MoH, 2015). This leaves many women in resource constrained areas with little access to information and other ANC services offered by CHW's. Subsequently, there has been a negative attitude by some community members towards the CHW's because some of them lack formal education (MoH, 2015; Kamwesiga, 2011). With the need to increase antenatal care attendance in Uganda, it's important to empower CHW's to offer their advisory and interventional roles to expectant mothers which could subsequently enable enhancing antenatal care decisions.

Some mothers prefer not to use community health workers but rather access services directly at the health facilities. However, because of shortage of midwives, delay to receive care, long distances, poor services offered in health facilities among others, this has limited on the amount of information and other related services that can be accessed at the facilities, which in the long run is detrimental to the decision making ability of mothers.

2.3 Risk Factors and Health Outcomes for Non-use of Antenatal Care Services

Antenatal Care

ANC aims to promote healthy behaviours in pregnant women and provide early detection and treatment for complications (Dodd, 2002; Godia, et al. n.d). To support ANC, services should be available to pregnant women in health facilities. ANC services involve tetanus toxoid immunization service, counselling services, physical examination like foetal heart sound, laboratory tests including urine to check for protein and sugar, blood test usually for malaria and HIV/AIDS, and preventive services which include taking of iron and folic tablets (Conrad, et al. 2012; Godia, et al. n.d). Improving ANC visits puts mothers in better position to get information on how best to handle certain situations in order to get better maternal health outcomes. For example information concerning HIV/AIDS, danger signs, anaemia, maternal nutrition and weight, blood pressure management and control, drugs and supplements among others. This information is important because it helps a mother make antenatal care decisions and improve chances of preventive interventions during pregnancy (Godia, et al. n.d). ANC allows high-risk screening of mothers and provides an opportunity to promote health and health seeking behaviour among mothers (Carroli, Rooney & Villar, 2001).

Maternal Nutrition

MoH (2010e) report defines maternal nutrition as the nutrition of a woman during any stage of her reproductive age which eventually affects her health and that of her foetus or infant. There's need to eat well during pregnancy (Van de Sande, 1999) to intensify the pregnant woman's nutrient needs otherwise MoH (2010e) postulates that this could increase the risk of pregnancy complications. The MoH (2010e) report puts the deaths attributable by maternal malnutrition in Uganda to 20 percent. Malnutrition was observed to increase the incidence and fatality rate of the conditions that contribute to the 80 percent of maternal deaths (MGD, 2016). Maternal anaemia, a component of maternal nutrition, contributes to 24 percent of maternal deaths in Uganda (FANTA-2, 2010) and was estimated to increase to 15,000 women by end of 2015

(Uganda PROFILES, 2010). Under nutrition weakens the woman's ability to survive child birth translating it into maternal/neonatal mortality or morbidity (MoH, 2010e) and may influence foetal programming, priming the child to be susceptible to high blood pressure, diabetes later in life (Brown, n.d). The underlying causes of maternal malnutrition are food insecurity, inadequate maternal practice, inadequate dietary intake, lack of knowledge and / or education (NPA, 2015; Shekar et al. 2013; FANTA-2, 2010). Majority of the mothers do not have access to information despite the existence of multiple intervention to address the issue of maternal malnutrition (MoH, 2010e; FANTA-2, 2010). Information such as the foods permissible to pregnant women, food groups and their nutritional value to pregnant women, the quantity and frequency of consumption which is paramount for expectant mothers in order to make nutrition-based decisions.

Maternal obesity (BMI > 30) and maternal overweight (BMI = 25 to 29.9) increases the risk of birth defects in babies and twice the risk of heart abnormalities (Brown, n.d). Obesity contributes to 28% of maternal deaths in Uganda (Kabayambi, 2014). On the contrary, underweight mothers prior to becoming pregnant put their babies at high risk of complications such as heart disease, diabetes, and high blood pressure later in life because of their association with malnutrition (Ehrenberg et al. 2003). A BMI less than 18.5 has been associated with preterm delivery which calls for close monitoring of underweight pregnant women to ensure that they adhere to their nutritional needs during pregnancy, with great emphasis to weight gain (Hauger et al. 2008), likewise maternal obese or overweight pregnant woman should closely be monitored to avoid any weight gain and gradually lose some by sticking to a particular diet. Pregnant women in Uganda with no education and those that lack sufficient information have been hit hard with the dire consequences of maternal underweight with Karamoja, Western and Southwest Uganda being the worst hit (UBOS and ICF, 2012).

Because maternal weight is correlated with nutrition, therefore information regarding special nutritional needs during pregnancy and signs and symptoms that may indicate a problem should be a routine component of antenatal care (Godia, et al. n.d) to help enhance nutritional decisions in order to improve maternal health outcomes. Consequently, this also calls for high levels of collaboration to bridge the information gap and build trust among mothers, community health workers and health experts.

Management of Pre-eclampsia

Pre-eclampsia is one of the leading causes of maternal, neonatal mortality and morbidity worldwide, but worse in the low and middle income countries (Khan, et al. 2006) contributing to 14% of maternal deaths (WHO, 2015a; Kabayambi, 2014; WHO, 2013a). Some of the risk factors associated with pre-eclampsia is maternal obesity, advanced maternal age, primigravidae, low social economic status among others (Namagembe, 2016; Silva et al. 2008; Hartikainen et al. 1998). Of the 50 pre-eclampsia cases admitted at Mulago hospital every month, at least one mother is lost (Namagembe, 2016) and pre-eclampsia has been sited one of the major causes of maternal deaths in Mulago hospital, a national referral hospital in Uganda (Nakimuli, et al. 2014) and the second overall leading cause of maternal mortality in Uganda ((MoFPED, 2015a). This therefore necessitates regular antenatal care (Bilano et al. 2014) to facilitate early diagnosis and management of the condition. Information that mothers need to better manage this condition and perhaps make informed decisions include, symptoms of pre-eclampsia, how to prevent it, who to contact, when and where to go in the event that symptoms persist. Nakimuli, et al. (2014) contend that mothers who are informed about preeclampsia are twice less likely to be affected by the condition unlike their counterparts, thus providing sufficient information to pregnant women improves their decision making ability to respond to the condition whereas, a need to emphasize collaboration with health experts who can identify and counsel pregnant women at risk is vital.

Other important areas in antenatal care worth emphasizing and strengthening in order to improve maternal health outcomes are immunization of tetanus, urine tests, blood tests and administration of iron and folic tablets. For all these services, mothers ought to make decisions about where to access these services; the cost of the services; medical expert with whom to consult; when to access the service; the type of tests to do and the prescription tablets to take. Subsequently, a mother's decision on the delivery method (vaginal delivery, caesarean section, vaginal birth after a caesarean, vacuum extraction, forcep delivery) may be made at this stage of the pregnancy though it is bound to change during the delivery stage. This decision making process can be aided by a collaboration of medical experts, peer mothers and community health workers.

Emergency Obstetric Care

Knowledge of obstetric danger signs is aimed at enhancing the utilization of skilled care in both low risk and emergency obstetric cases in low income countries (JHPIEGO, 2004). It is

important for women to be made aware of the obstetric danger signs during pregnancy, intra-partum and postpartum periods (WHO, 1994) with an aim of using this information to empower their decision to seek care from a skilled attendant in case of an emergency (Pemba, 2009). Antenatal care providers need to strengthen women's knowledge about danger signs and ensure that mothers know where to get help should these signs occur (WHO, 2002b). In the study conducted by Kabakyenga et al. (2011), the prevalence of knowledge of at least three danger signs during the three phases; pregnancy, childbirth and postpartum was very low at nineteen percent (19%). The low levels of awareness of danger signs contributes to the delay to seek care from a skilled attendant leading to high maternal mortality and morbidity (Kabakyenga et al. 2011). With only 48% of women attending the required four ANC visits and 66.9% not going for postnatal check-up (UDHS, 2011), the reduction in maternal mortality and morbidity can be achieved by promoting knowledge of danger signs and complication readiness (MoH, 2009c).

Most important of all, a woman should have an informed choice which National Health and Medical Research Council, (2010) rightly puts as the "autonomy and control to make decisions about her care after a process of information exchange that involves providing her with sufficient, evidence-based information about all options for her care, in the absence of coercion by any party and without withholding information about any options".

2.4 Decision Making Among Expectant Mothers – Theoretical Account

Paulus and Yu, (2012) define decision making as "a complex process of transforming options in actions based on certain metrics that represent the importance of these options to an individual." Decision making in antenatal care is not a solitary process but involves many stakeholders who work harmoniously towards providing a decision enabling environment for the mothers. In the context of this research, the stakeholders include peer mothers, community health workers and midwives. The active participation of stakeholders shapes the quality of service delivery that mothers ought to get.

Mothers are filled with a lot of decisions during the pregnancy period yet questions regarding to how we should (normative theories) or how we make (descriptive theories) decisions do not have clear cut answers. These questions can be answered using different theories in the field of decision science.

Most of the decisions are not temporary and often they take time that's why dividing them in phases is the most plausible idea. According to Simon (1960), decision-making consists of three principal phases: "finding occasions for making a decision; finding possible courses of action; and choosing among courses of action." Although, in certain circumstances for example variations in human behaviour, may lead to decisions not to be arrived at using a step-by-step process but rather a non-sequential format as explained by (Hoch et al, 2001; Heracleous, 1994; Mintzberg, Raisinghani & Theoret, 1976). In their view, decisions constitute distinct phases but they don't have a simple sequential relationship. The rational decision making practice can apply to simple, unambiguous and known problems but in the world of multiple stakeholders and complex problems with high degree of unpredictability and uncertainty like maternal health, rationality becomes inapplicable (Heracleous, 1994).

Mothers in the process of making decisions especially in unpredictable situations like during emergencies, may often require using heuristic strategies (Barby & Krieger, 2014; Todd et al. 2011), which may downplay the use of rational decision making. A heuristic is a decision strategy that ignores part of the available information and focuses on a few relevant predictors with a goal of making decisions more faster, frugally and more accurate. (Williams & Brown, 2014; Marewski & Gigerenzer, 2012; Elwyn, et al. 2001). Mothers relying on heuristics, make sound decisions with little information in the shortest time possible hence Marewski & Gigerenzer's (2012) "fast and frugal" construct. Gigerenzer and Gaissmaier, (2011) stated that in the process of decision making, the mind applies logic, statistics and heuristics. They further explain the heuristics model of decisions making, as being bound by two constructs, 1) that an individual relies on simple heuristics in an adaptive way, and 2) ignoring part of the information that can lead to more accurate judgement than weighting and adding all the information. Heuristics are appropriate for certain situations like emergency situations mothers may experience during pregnancy.

Sometimes mothers seem to employ the unbounded rationality decision strategy, which assumes that the decision maker (mother) collects and evaluates all the information, weight each piece of it according to some criterion and then combine all the pieces to maximise the chances of attaining a goal (Marewski & Gigerenzer, 2012) for example seeking the best hospital while minimizing the cost of reach. This has been evidenced in some situations where mothers consult their peers, relatives or community health workers on issues regarding pregnancy in a bid to gather as much information as possible before making a decision. It is asserted that the more informed a decision maker is, the more likely of them making informed

decision as is with the utility theory (Hibbard et al. 1997). The theory posits that the more individuals are adequately informed, they make choices that maximise their interests. It has also been postulated that acting hastily without giving due planning and deliberation may cause harm (Rall and Flin, 2008) for the decision makers.

As discussed earlier, it was noted that culture, distance, timing, access to information were highly reflected as factors influencing decisions. Several scholars (Oliveira, 2007; Stein and Welch, 1997) contend that different factors like cognitive psychology, belief, culture might influence and corrupt information processing thereby bringing a variation in the decisions. Culture directs people's actions and behaviour in decision making (Trompenaars, 1994; Schein, 1992). Gigerenzer & Goldstein's (1996) ecological rationality theory acknowledges that people make decisions under constraints of time, knowledge, or analytical ability.

Collaboration in health care is necessary to ensure comprehensive service delivery (Ellingson, 2002). Antenatal care involves multiple stakeholders and mother's decisions are sometimes influenced by their peers in the social network. This is supported by the social cognitive theory which posits that people learn not only through their experiences, but also by observing what others do and the results from their actions (McAlister, et al. 2008; Bandura, 1986).

As earlier discussed, decision making among mothers is sometimes hinged on their age, personal values, personality (William & Brown, 2014) and/or emotions (Peters et al. 2009). Using the appraisal tendency framework which provides a theoretical foundation that emotions give rise to corresponding cognitive and motivational processes affecting decision making (Ferrer, n.d; Bower, 1991; Forgas, 2003; Isen, 1993), we see this fitting well within the mother's context in Uganda. Emotions are thought to influence someone's intuitive and analytical extents that contribute to decision making as posited by (Evans, 2008; Beresfold & Sloper, 2008). A number of researchers (Kahnemann and Frederick, 2002; Hogarth, 2001; Epstein and Pacini, 1999; Sloman, 1996) contend that human reasoning holds two different systems when processing options in decision making condition; system 1, which is conceived as automatic, unconscious, implicit and associative and system 2, which is viewed as explicit, rational, rule-based and analytic. This culminates into the dual-systems theory of human reasoning.

In assessing the kind of decision support to adopt to a particular problem, it is important to note that health decisions are unique in at least two respects i) the decision which may be

consequentially beneficial for an individual (mother), it may affect the performance of the health service delivery and ii) there are no clear "right decisions" (Hibbard et al. 1997).

On the other hand, this research has an inclination to the product and technology framework that provides principles, models, concepts and guidelines for delivering interoperable mobile solutions for maternal health (GSMA, 2014). The P & T framework revolves around building technology infrastructure that integrates services through providing a single national cohesive platform for the different stakeholders to collaborate. The framework focuses on bringing together existing maternal health services, mHealth applications and solutions that are already existing in Uganda. Unlike the focus of this research which is ultimately antenatal care, the P&T framework looks at incorporating all aspects of maternal health like postnatal care, neonatal care among others.

2.5 Application of Mobile Health (mhealth) in Antenatal Care

Mobile health is a practice of medicine and public health using mobile technology such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless technologies (Adibi, 2015; WHO, 2011a). WHO (2011a) highlights fourteen categorizes of mhealth services namely; i) health call centres, ii) managing emergencies and disasters, iii) mobile telemedicine, iv) emergency toll-free telephone services, v) community mobilization and health promotion, vi) treatment compliance, vii) appointment reminders, viii) information access, ix) health surveys and data collection, x) mobile patient records, xi) patient monitoring, xii) health awareness raising, xiii) surveillance, xiv) decision support systems. But according to the survey by Global Observatory for eHealth, the least frequently used mHealth service is surveillance (26%), raising public awareness (23%) and decision support systems (19%) basically because of the enhanced capability and infrastructure to implement (WHO, 2011a).

Mobile technology has been fronted as one of the ways of improving health service delivery including maternal health in low resource settings (Lavender et al. 2013; WHO, 2011a). In 2014, there were 19.5 million mobile phone subscribers and 4.2 million internet subscribers in Uganda contrary to 18.3 million mobile phone subscribers and 3.6 million internet subscribers in 2013 (UCC, 2014). This indicates an exponential growth in the use of mobile technology specifically mobile phones.

World over, use of mhealth systems has proved to be an efficient way of improving health service delivery. According to Lippeveld et al (2000), health information system is taking

decision making closer to the beneficiaries of health services. It should be noted that mhealth applications have a number of benefits to expectant mothers, including but not limited to; i) positively influencing mothers to engage with the health facilities which include attending antenatal care early in their pregnancy, attend all the recommended antenatal care visits and delivery at the health facility, ii) reduce on the three delays, iii) improving monitoring and evaluation of health systems activities for enhanced decision making iv) greatly impact women who lack access to essential healthcare and nutritional information (GSMA, 2016; MAMA, 2012). Mhealth systems have been used in emergency services, measuring blood pressure, foetal heart monitoring, information dissemination and diagnostics among others.Several scholars (e.g. Zanden, 2014 and Boyd, 2012; Lee, 2009 and Nabanoba, 2005; Sarmiento, 2011; mHealth alliance, 2012; Ahsan, and Raihan, 2013; Mehl, 2010; Kaewkungwal et al. 2010; Lund & Hemed, 2010; Mechael, 2009; GSMA, 2016; Ngabo et al. 2012) have documented the extent of technology usage to support decisions of expectant mothers. These different applications address particular aspects of antenatal care for example detecting problems in the womb, emergency medical support, SMS-based platforms that increase women's awareness of pregnancy related issues among others.

WinSenga was an innovation that had a funnel-like pinnard horn similar to the one used by midwives. It had a highly sensitive microphone that is placed on a pregnant woman's abdomen connecting to a windows based phone running an app to detect problems such as ectopic pregnancy or abnormal foetal heart beats (Zanden, 2014; Boyd, 2012). An SMS appointment reminder system which is a standalone service in Philippines where mothers registered to a local health centre received appointment reminders 2-3 days prior their scheduled appointment (Sarmiento, 2011). The mCheck initiative in India that assists the identification of risk factors in mothers and new-borns during the week-long high risk period after delivery (mHealth Alliance, 2012). Mobile alliance for maternal action (MAMA) implemented a service in Bangladesh, India and South Africa to offer information to expecting mothers in text message format adapted to different contexts (Ahsan, and Raihan, 2013). Wired mothers was a project in Tanzania that aimed at strengthening communication between expecting mothers and health centres through a mobile phone by asking questions about acute and non-acute problems to limit on unnecessary visits to hospitals (Lund and Hemed, 2010). Mobile for Reproductive Health (m4RH) implemented in Kenya and Tanzania was a service targeting both men and women to receive information on family planning methods (Mehl, 2010). MoTECH, an initiative in Ghana was aimed at increasing the quality and quantity of prenatal and neonatal

care in rural Ghana (Mecheal, 2009). This mHealth initiative enables a pregnant woman to receive SMS or pre-recorded messages on their mobile phones and allows a community nurse to identify pregnant women in the community and electronically record care given to patients.

Text-To-Change, an SMS based program in Uganda that was aimed at sending text messages to mothers reminding them to go for ANC (Fazekas and Moffett, 2009). The Mother and Child Care Module (MCCM) instituted in Thailand was a two year program where mothers received message reminders to go for ANC (kaewkungwal et al. 2010). Kilkari delivers free, weekly, time-appropriate audio messages about pregnancy and child birth to the families' mobile phones from the second trimester until child is one year old (GSMA, 2016). RapisSMS-MCH system was an SMS based platform introduced in Rwanda between 2010 and 2011 to allow interactive communication between the CHW and the mothers (Ngabo et al. 2012).

Hasvold and Wootton (2011) posited that message reminders reduced patient no-shows by almost a third and that reminders improved attendance and reduced non-attendance. Guerena (2015) also noted that text messages had a greater impact on women from economically deprived conditions with 28 per cent of them more likely to go to hospital if they received a reminder.

The walkie-talkie initiative introduced in Uganda, Mali, Ghana, Malawi and Sierra-Leon from 1996 to 1999 was aimed at improving access to emergency obstetric care and referral systems. Traditional Birth Attendants and/or midwives were given walkie-talkies to contact supervisors or ambulances in the case of emergency (Lee et al. 2009; Nabanoba, 2005). This initiative was noted to have substantially reduced maternal deaths, however Krasovec (2004) stated that this approach had a weak empirical evidence regarding the actual impact of such systems and their influence in reducing maternal deaths. Camielle et al. (2011) further noted that the tight timeframe between when a mother experiences an emergency for example bleeding, and when she accesses medical help requires that quality services are accessed in the shortest time possible and supported with effective infrastructure management. This radio system was later replaced by the mobile phones which were found accessible, cheaper and a much more practical solution (UNFPA, 2007).

A significant number of mHealth applications have been developed and implemented, often resulting in a complex system of overlapping services. As a result, one of the most important current limitations of mHealth and its ability to deliver solutions is the fragmentation between different mHealth applications providing both similar and different functionality across

geographic regions, health services, levels within the health system as well as the continuum of care (Kearney, 2012; William, 2013). The consequence as a result of the detached and standalone mHealth strategies is that the benefits accrued from each siloed application are outweighed by those of an integrated system which is why William (2013) posits this to be one of the reason most of these mHealth strategies die in their pilot phase.

Research reveals a lack of evidence-based studies focusing on the efficacy and effectiveness of maternal mHealth applications (Camielle et al. 2011).

Critical areas receiving a lot of attention in the world of global health is the strengthening of community systems (Marchal, 2009) which, among others, involves enabling effective service delivery, coordination and collaborative working relationships (William, 2013) which is lightly reflected in the current mHealth strategies.

Following the above discussion, we note that different mHealth strategies for maternal health address dissimilar and in some cases related aspects of maternal health. However, William (2013) recommends the use of mobile phones as decision support tools to implement integrated health services. Antenatal care is a complex and volatile matter with processes and decisions interrelated requiring each aspect not to be treated in isolation.

The complexity of antenatal care involves various stakeholders who play distinct roles in the life of an expectant mother. Pregnant women can be reached through extended caretakers in their communities, which is lightly addressed in the current mHealth interventions yet mHealth Alliance (2012), advocates for mHealth interventions that target these people such as peers or influential community members because this can facilitate the knowledge transfer of appropriate care, as well as encourage mothers to seek services. Mhealth can also create peer networks of pregnant women or partner first-time mothers with experienced mothers for support (mhealth alliance, 2012).

Mhealth intervention strategies are being used to overcome factors that limit access, such as social marginalization, geographical distance to services, lack of financial resources or inadequate skilled personnel (William, 2013; Kaewkungwal et al. 2010) and mobile phones require basic literacy making them accessible to a large segment of the population (Rashid & Elder, 2009). It is against this background that the technology intervention to enhance pregnant women's decisions should be all encompassing, highly collaborative, agile and interactive.

Table 2-1: Analysis of existing mHealth strategies

Functionality	mHealth Strategies/Applications											
	mCheck	MAMA	WinSenga	Wired Mothers	M4RH	MoTECH	Text-To-Change	MCCM	Kilkari	RapidSMS	Walkie-Talkie	Antenatal Care Studio
SMS		✓		✓	✓	✓	✓	✓		✓		✓
Pre-recorded Audio Messages	✓								✓			
Mobile App			✓									
Mobile Web Platform												✓
Radio call system											✓	
Video												✓
1-Way Mode	✓	✓	✓		✓	✓	✓	✓	✓			
2-Way Mode				✓						✓	✓	✓
Emergency Response and Reporting											✓	✓
Online Training												✓
Self-Paced Training												✓
Collaborative Engagement												✓
Instant Messaging												✓
Antenatal Care Alert												✓
Weight tracking												✓
Preeclampsia symptom monitoring												✓
Nutrition Tracking												✓
Decision Enhancement			✓		✓							✓

Table 2-1 above provides a summary of an analysis of existing mHealth strategies in the region and in other parts of the world. The focus was majorly on regions with alarming maternal mortality rates and these include Asia and Africa. Whereas a lot has been done in increasing awareness of antenatal care, many of these approaches are SMS-based with very limited services. One of the biggest challenges with SMS-based mHealth strategies is the number of characters per text message which is a hindrance as some health messages may be quite long (Kiria, 2012) and also one-way communication limits engagement between the expectant mothers and the care providers. The figure below illustrates the different mHealth strategies so far implemented in Uganda. These strategies offer different services ranging from HIV/AIDS awareness, monitoring drug supplies and distribution, birth and death registration, collecting health data, monitor community events in pregnant women, education and training services, surveillance and reporting disease outbreaks.

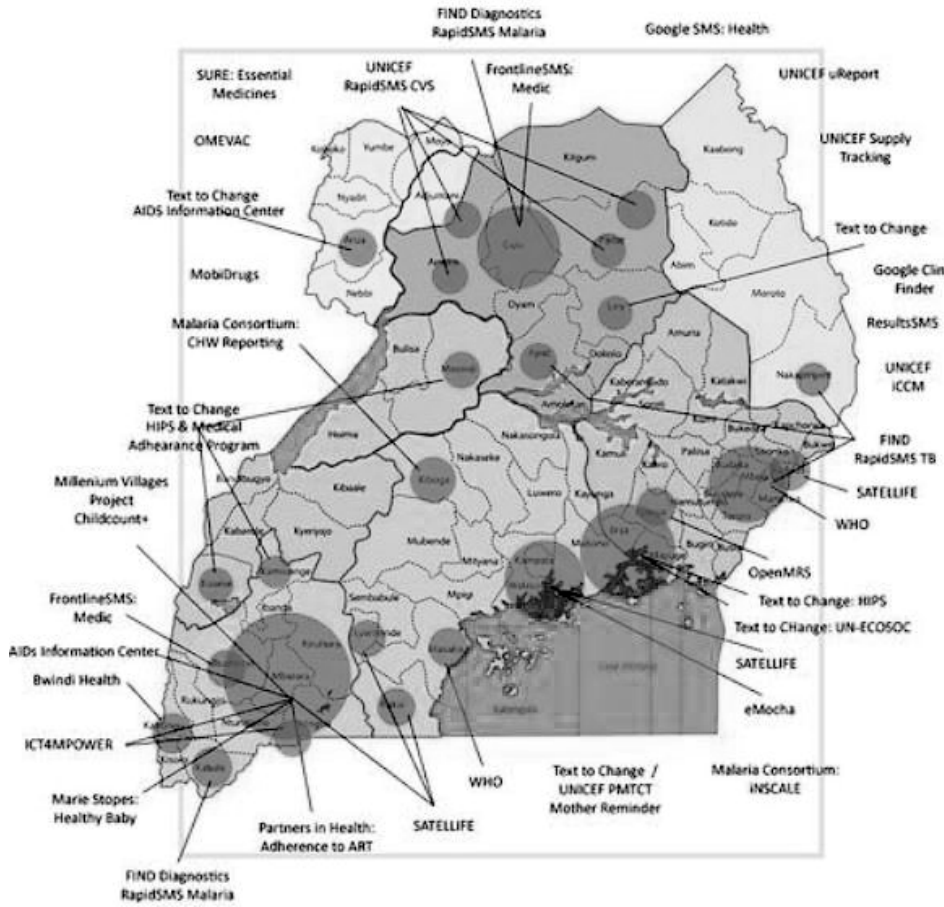

Figure 2-1: Map of mHealth Pilots in Uganda by Sean Blaschke (Adopted from: Leap, 2014)

2.6 DE and Antenatal Care in Uganda

From the discussion above, it should be noted that many of these mHealth strategies implemented in Uganda lack a decision support component because of the nature of services that they offer, yet to be able to holistically deal with antenatal care issues and enhance decisions, there should be different divergent sources of information. We therefore note that;

- Antenatal care is a complex issue involving dynamic, unpredictable and uncertain situations
- Decisions therein are dependent on each other
- Antenatal care involves multiple stakeholders whose involvement affects the expectant mother's decisions

- The mhealth strategies implemented so far offer a limited scope in decision support and decision enhancement.

In order to deal with this issue, the study was anchored on decision enhancement principles (Keen and Sol, 2008) because of the powerful DE capabilities which are collaborative and engaging. Firstly, the choice of using DE is hinged on the fact that different scholars (Tumwebaze, 2016; Katumba, 2016; Mirembe, 2015; Aregu, 2014; Mercy, 2012) successfully employed it to solve complex problems in the East African context. Secondly, DE was opted because no research shows its application in the antenatal care field in Uganda. Thirdly, the choice of using decision enhancement is because it emphasizes decision process agility which is characterized by *speed, flexibility, coordination and collaboration* (Keen and Sol, 2008). These aspects fit well with antenatal care decision making practices of expectant mothers.

Speed of a process is an essential part of decision making (Keen and Sol, 2008) if a pregnant mother is to respond to the ever-changing conditions surrounding her environment.

Flexibility is an important aspect to respond to the growing uncertainty and volatility (Keen and Sol, 2008) of the pregnant woman's environment.

Coordination requires that decision processes are well aligned across functions, geography, stakeholders and partners (Keen and Sol, 2008). Kolfschoten (2007) defines coordination as "arrangement of a joint effort towards a goal".

Collaboration is key to handling complexity because no single actor possess all the skill or information to make effective decisions (Keen and Sol, 2008). Kolfschoten (2007) defines collaboration as "a joint effort towards a goal". In the DE perspective, collaboration involves a blend of people, process and technology (Keen and Sol, 2008) jointly working together to form a collaboration system. According to Briggs et al. (2009), a collaboration system is "*combination of actors, hardware, software, and knowledge and work practices to facilitate groups in achieving their goals, in an effective and efficient way".* Antenatal care is a field that operates in a multi-stakeholder environment where a pregnant woman's decisions largely depends on the consultation with the different stakeholders within the antenatal care cycle.

CHAPTER 3 – EXPLORATION

This chapter delves into the survey that was conducted in Kampala and Jinja districts. The main objective of this survey was to try and gain a deeper understanding on issues pertaining to antenatal care practices. 3.1 discusses selection of case studies, 3.2 presents results, 3.3 discusses the results, 3.4 offers a generic understanding and 3.5 discusses the design considerations of the ACS.

3.1 Case Selection

The study was carried out in two districts of Kampala and Jinja between January to April 2015. Kampala being the second most populated city in Uganda with more than 1.5 million residents and Jinja the fifth with slightly more than 70,000 residents (Uganda Bureau of Statistics, 2016) were chosen. The choice of Jinja was based on the fact that there are many community engagement projects with mothers. Kampala was used in order to clearly bring out the rural-urban divide between these two regions. Using multiple cases in exploration offer a robust framework for data collection (Remenyi et al. 1998). In Kampala, Mengo Kisenyi and Kasubi Kawaala were used while in Jinja, Walukuba and Mpumudde were selected. The study focused on expectant mothers and mothers with children below two years in order to get responses that echo recent incidences.

A baseline survey was conducted in the following manner. In Walukuba, a total of 8 mothers were interviewed, N=3 were pregnant and N=5 were mothers with children below two years. In Mpumudde, 6 women were interviewed, N=2 were pregnant and N=4 were mothers with children below two years. In mengo Kisenyi, 10 participated, N=2 were pregnant and N=8 were mothers with children below two years. In Kasubi Kawaala, 11 participated, N=3 were pregnant and N=8 were mothers with children below two years. A total of 35 respondents participated in the baseline survey. The purpose of the baseline survey was to get an understanding of the current status of antenatal care before an indepth study was conducted. Baseline studies are important in order to establish key priority areas of the study and provide quantitative information on the current status (Mwania, 2015; FAO, 2013).

After the baseline study, questionnaires were distributed to 250 respondents and 164 were successfully returned. All women who participated were ranging between 18 to 50 years and had completed primary school education. This survey was conducted to;

- Assess the uptake and challenges hindering antenatal care access.

- Find out the type of information expectant mothers use to aid decision making.
- Explore incidences during antenatal that trigger decision making.
- And lastly, suggestion on how to improve access to information in order to improve decision making among expectant mothers.

Themes on the questionnaire were guided by the outcome of the preliminary baseline survey that was conducted together with information found in literature. Consent to conduct this survey was sought from the local council leaders and all women who participated gave a verbal consent while others sought consent from their spouses. House holds that were located in urban, peri-urban and rural were selected to represent a rural-urban divide.

Sampling Strategy and Procedure: Non probability sampling was used to select respondents because the study population was not known. Under non probability sampling, purposive sampling was used based on the knowledge of the research issue and willingness of the respondents to participate in the research (Getu, 2006).

In Uganda, each parish has more than twenty zones, out of these the survey focused on two zones in each parish and an approximate total of 80 households in each zone was visited with anticipation that more than half of these would have a pregnant woman and a mother who had given birth at least not more than two years earlier. Houses that were close to the main road or a trading centre offered a starting point and the subsequent houses followed in sequel. On average 9 pregnant women and 31 mothers with children below two years in each parish participated in the survey.

Data Collection: From the baseline survey, a questionnaire with four themes was drafted. These themes were presented into four sections; section A - was on demographics; section B – focused on general information on parity, source and type of information expectant mothers use to aid decision making, conditions that trigger decisions to seek care and challenges that prohibit access to antenatal care services; section C – looked at antenatal care services; D – use and uptake of ICT. Two trained research assistants together with one female local resident guided the house to house distribution of questionnaires. A questionnaire had both open-ended closed-ended questions and before the study was rolled out, the questionnaire was pre-tested with the women of Lubya zone, an area that was not part of the survey. The choice of using both open and closed questions was because opened ended questions gave deeper and new insights into while closed ended questions were used because the survey was relatively large and they are easy to answer (Farrell, 2016; Reja et al. 2004).

Each household was approached by a research assistant who first presented their identification to seek consent from the house head. They later inquired if there was a pregnant woman or a mother with a child below two years old present. Those households that fit the criteria were given questionnaires. Women who could not comprehend the content of the questionnaire were guided by the interviewers in a verbal one-on-one interaction which to a certain extent entailed translating the content in local languages. However, use of antenatal care cards to capture the number of times a woman had attended antenatal care, parity and their age was very minimal because most of them especially those that had given birth had either lost or discarded the cards.

3.2 Presentation of Results

This section presents results from quantitative survey and discussion of findings.

Demographics and General Information

More than 85% of women (140/164) in the age bracket 18-35 had given birth with the greatest number 82(58%) being in the age between 18 and 25 (see table 3-1).

Kampala

Out of the 164 respondents, 83 were from Kampala, and of these 76(91%) had at least a child, with majority of them in the age bracket 26-35 years (see table 3-1 and 3-2).

Among women who responded to the study, majority of the respondents had finished tertiary 17(20.7%) and university 18(22%). In this region, 23(27.7%) were pregnant and 60(72.3%) were mothers with babies less than two years (see table 3-1). The major sources of information for pregnant women were midwives 39(69.9%) followed by community health workers 1(5.6%). The least commonly used source of information in this region were peer mothers 26(39.4%) (See table 3-3).

Women in Kampala 52(62%) had fair knowledge about the information necessary to aid decision making with 31(31%) not sure at all (see table 3-4).

Half of the respondents in Kampala agreed on having autonomy to influence and make their own antenatal care decisions while the rest didn't (see table 3-5).

Of the 82 respondents that do not influence their decisions, 42 were from Kampala. And of the 42 respondents, 12(28.6%) entirely depended on their spouses for decisions, 15(35.7%) on midwives, 13(31%) on CHW and 2(4.8%) on peers (see table 3-6).

Reasons why women didn't control their decisions were attributed to lack of knowledge about antenatal care 16(39%), husband being the economic provider 14(34.1%), lack of experience and exposure 2(4.9%) and 2(4.9%) on Culture (see table 3-7).

43% of the respondents in Kampala cited lack of enough information as one of the major challenge prohibiting access to antenatal care services. Lack of money 15%, long distance 6%, inadequate services at hospitals 31%, and cultural inclination 2% are more challenges mothers face in accessing antenatal care services (see table 3-8).

Jinja

There were 81 women who responded to the survey and 76(93%) had at least a child. Unlike Kampala, more than half of the respondents 52(63%) in Jinja fell in the age bracket of 18-25 (see table 3-1).

A paltry 2(5.5%) had finished tertiary and 13(16%) university more than half of the total number of respondents in this region had attained primary 35(43.2%) and secondary 31(38.2%) education (see table 3-1). In this region, the highest number of respondents 52(64.2%) were in the ages 18-25. And 19(23.5%) were pregnant and 62(76.5%) were mothers with babies less than two years (see table 3-1).

Midwives 39(50.6%) and community health workers 19(24.7%) were the greatest source of information for expectant mother. However, peers 9(11.7%) and family friends 6(7.8%) equally contributed to providing information to mothers though at a smallest percentage (See table 3-3).

Of the 81 respondents, 56(57.7%) were not solely responsible for making their own decisions (see table 3-5).

More than half of the respondents 56(57.7%) in this region do not influence their antenatal care decisions with many 19(47.5%) depending on their spouses. The remaining 21(52.5%) respondent's decisions were determined by their midwives, peers and community health workers (See table 3-5 and 3-6).

Lack of knowledge about antenatal care (57%) and husbands being the financial provider (30%) were the dominant reasons women in Jinja did not influence their decisions (See table 3-7).

The lack of information (38%) and money (13%), long distances (19%), culture (7%) inadequate and poor services (21%) were challenges that prohibited women in Jinja from utilizing antenatal care services (see table 3-8).

Table 3-1: Demographics of the respondents

Number that participated and returned questionnaires	Number/Percent of Mothers N=164	
	Kampala	Jinja
Number of Respondents	83	81
Education Level		
Primary	19(23.2%)	35(43.2%)
Secondary	28(34.1%)	31(38.3%)
Tertiary/Vocation	17(20.7%)	2(2.5%)
University	18(22%)	13(16%)
Age		
18-25	30(36.1%)	52(64.2%)
26-35	38(45.8%)	20(24.7%)
36-45	12(14.5%)	7(8.6%)
46-50	3(3.6%)	2(2.5%)
Status		
Pregnant	23(27.7%)	19(23.5%)
Mother with baby less than two years	60(72.3%)	62(76.5%)
Parity		
None	7(8.4%)	5(6.2%)
One	14(16.9%)	12(14.8%)
Two	27(32.5%)	38(46.9%)
Three	22(26.5%)	18(22.2%)
Four and above	13(15.7%)	8(9.9%)

Table 3-2: Location * Age

			Age				
			18-25	26-35	36-45	46-50	Total
Location	Kampala	Count	30	38	12	3	83
		% within Age	36.6%	65.5%	63.2%	60.0%	50.6%
	Jinja	Count	52	20	7	2	81
		% within Age	63.4%	34.5%	36.8%	40.0%	49.4%
Total		Count	82	58	19	5	164
		% within Age	100.0%	100.0%	100.0%	100.0%	100.0%

Table 3-3: Who is your major source of antenatal information * Location

			Location		
			Kampala	Jinja	Total
Who is your major source of antenatal information	Peer mothers	Count	9	22	31
		% within Location	11.7%	27.5%	19.7%
	Midwives	Count	39	20	59
		% within Location	50.6%	25.0%	37.6%
	Family and friends	Count	6	1	7
		% within Location	7.8%	1.3%	4.5%
	CHW	Count	19	36	55
		% within Location	24.7%	45.0%	35.0%
	My experience	Count	4	1	5
		% within Location	5.2%	1.3%	3.2%
Total		Count	77	80	157
		% within Location	100.0%	100.0%	100.0%

Table 3-4: Location * What kind of information would you use to aid your decision making

		Location		
		Kampala	Jinja	Total
What kind of information would you use to aid your decision making	Nutritional Information	2.4%	3.7%	3.0%
	Lab test results	10.8%	2.5%	6.7%
	Information on Preeclampsia	6.0%	2.5%	4.3%
	Information on Danger Signs	10.8%	3.7%	7.3%
	Info. on types of services offered	8.4%	3.7%	6.1%
	All the above	4.8%	11.1%	7.9%
	Not sure	37.3%	58.0%	47.6%
Total		100.0%	100.0%	100.0%

Table 3-5: Location * Are you solely responsible for making your own antenatal care decisions

		Are you solely responsible for making your own antenatal care decisions		
		Yes	No	Total
Location	Kampala	62.1%	42.3%	50.3%
	Jinja	37.9%	57.7%	49.7%
Total		100.0%	100.0%	100.0%

Table 3-6: Who makes your decision * Location

			Location		Total
			Kampala	Jinja	
Who makes your decision	Spouse	Count	12	19	31
		% within Location	28.6%	47.5%	37.8%
	Midwife	Count	15	3	18
		% within Location	35.7%	7.5%	22.0%
	Peer mothers	Count	2	5	7
		% within Location	4.8%	12.5%	8.5%
	CHW	Count	13	13	26
		% within Location	31.0%	32.5%	31.7%
Total		Count	42	40	82
		% within Location	100.0%	100.0%	100.0%

Table 3-7: Why is it that you don't make your decision * Location

			Location		Total
			Kampala	Jinja	
Why is it that you don't make your decision	I don't know a lot about antenatal care	Count	16	32	48
		% within Location	39.0%	57.1%	49.5%
	My husband provides the money	Count	14	17	31
		% within Location	34.1%	30.4%	32.0%
	I do not know	Count	7	5	12
		% within Location	17.1%	8.9%	12.4%
	Lack of experience and exposure	Count	2	1	3
		% within Location	4.9%	1.8%	3.1%
	Culture	Count	2	1	3
		% within Location	4.9%	1.8%	3.1%
Total		Count	41	56	97
		% within Location	100.0%	100.0%	100.0%

Table 3-8: Location * What challenges prohibit you from accessing antenatal care services?

			Location		
			Kampala	Jinja	Total
What challenges prohibit you from accessing antenatal care services?	Lack of information regarding antenatal care services	Count	36	31	67
		% within Location	43.4%	38.3%	40.9%
	Lack of money	Count	13	11	24
		% within Location	15.7%	13.6%	14.6%
	Long distance	Count	5	16	21
		% within Location	6.0%	19.8%	12.8%
	Services at hospitals are inadequate	Count	26	17	43
		% within Location	31.3%	21.0%	26.2%
	None of the above	Count	1	0	1
		% within Location	1.2%	.0%	.6%
	Cultural Inclination	Count	2	6	8
		% within Location	2.4%	7.4%	4.9%
Total		Count	83	81	164
		% within Location	100.0%	100.0%	100.0%

Antenatal Care

Out of the 82 respondents in Kampala, 72% of these attended antenatal care in their previous pregnancy while in Jinja, only 39% had attended antenatal care (See table 3-9). Of those that attended antenatal care in Kampala, more than half had attended more than twice while in Jinja, only a paltry 21% had been to hospital more than twice (See table 3-10).

Of the 79 respondents who had given birth in a hospital, 36% had not attended any antenatal care and of the 84 respondents that had not given birth in a hospital in their previous pregnancy, 58% had attended at least one antenatal care (See table 3-11).

Of the 88 women that had attended antenatal care, 46% of those didn't give birth in the hospital and yet again 55% had neither attended antenatal care nor given birth in the hospital (See table. 3-12).

50% of the 68 respondents that had in fact not attended antenatal care had given birth with a presence of the skilled birth attendant (See table 3-13).

Majority of the respondents strongly agreed on knowing the importance of giving birth in a hospital (μ=4.24). On the other hand, many mothers did not know the danger signs of pregnancy (μ=2.51), symptoms and dangers of preeclampsia (μ=2.42); importance of antenatal care (μ=2.85), preventive services during pregnancy (μ=2.89), balanced diet during pregnancy (μ=2.92); causes of maternal death (μ=2.24), services offered in antenatal care (μ=2.25). However, some respondents moderately agreed on knowing foods that are permissible to pregnant women (μ=3.45) and the dangers of being over or under-weight before and after pregnancy (μ=3.01) (see table 3-14).

Table 3-9: Location * Did you go for Antenatal care (ANC) in your previous pregnancy?

			Did you go for Antenatal care (ANC) in your previous pregnancy?		
			Yes	No	Total
Location	Kampala	Count	59	23	82
			67.0%	33.8%	52.6%
	Jinja	Count	29	45	74
			33.0%	66.2%	47.4%
Total		Count	88	68	156
			100.0%	100.0%	100.0%

Table 3-10: Location * How many times did you go for ANC on your last pregnancy

			How many times did you go for ANC on your last pregnancy				
			One	Two-Three	Above 4	None	Total
Location	Kampala	Count	21	25	17	20	83
			52.5%	61.0%	94.4%	30.8%	50.6%
	Jinja	Count	19	16	1	45	81
			47.5%	39.0%	5.6%	69.2%	49.4%
Total		Count	40	41	18	65	164
			100.0%	100.0%	100.0%	100.0%	100.0%

Table 3-11: In my last pregnancy, I gave birth in a hospital * How many times did you go for ANC on your last pregnancy

			How many times did you go for ANC on your last pregnancy				
			One	Two-Three	Above 4	None	Total
In my last pregnancy, I gave birth in a hospital	Yes	Count	20	19	11	29	79
			50.0%	46.3%	61.1%	45.3%	48.5%
	No	Count	20	22	7	35	84
			50.0%	53.7%	38.9%	54.7%	51.5%
Total		Count	40	41	18	64	163
			100.0%	100.0%	100.0%	100.0%	100.0%

Table 3-12: Did you go for Antenatal care (ANC) in your previous pregnancy? * In my last pregnancy, I gave birth in a hospital

			In my last pregnancy, I gave birth in a hospital		
			Yes	No	Total
Did you go for Antenatal care (ANC) in your previous pregnancy?	Yes	Count	47	41	88
		%	53.4%	46.6%	100.0%
	No	Count	30	37	67
		%	44.8%	55.2%	100.0%
Total		Count	77	78	155
		%	49.7%	50.3%	100.0%

Table 3-13: Did you go for Antenatal care (ANC) in your previous pregnancy? * Have you ever been assisted through delivery without a presence of a skilled birth attendant

			Have you ever been assisted through delivery without a presence of a skilled birth attendant			
			Yes	No	It's my first time to be pregnant	Total
Did you go for Antenatal care (ANC) in your previous pregnancy?	Yes	Count	23	58	7	88
		%	26.1%	65.9%	8.0%	100.0%
	No	Count	34	31	3	68
		%	50.0%	45.6%	4.4%	100.0%
Total		Count	57	89	10	156
		%	36.5%	57.1%	6.4%	100.0%

Table 3-14: The results of descriptive statistics on Antenatal Care

	Mean	Mode	Std. Deviation
I know the value of giving birth from a hospital	4.24	4	.815
Have you ever been assisted through delivery without a presence of a skilled birth attendant	1.71	2	.586
In my opinion, I am aware of the danger signs of pregnancy	2.51	2	1.304
In my opinion, I know the importance of antenatal care during pregnancy	2.85	2	1.458
In my opinion, preventive services which include iron and folic are important during and after pregnancy	2.89	1	1.597
In my opinion, I know the importance of a balanced diet during and after pregnancy	2.92	2	1.482
In my opinion, I know the foods permissible to pregnant women	3.45	4	1.341
In my opinion, I know the dangers of being over-weight and under-weight before and during pregnancy	3.01	2	1.459
In my opinion, I know the importance of taking blood pressure measurements during and after pregnancy	2.79	2	1.450
In my opinion, I am aware of the symptoms and dangers associated to pre-eclampsia	2.42	2	1.365
I am aware of the causes of maternal deaths	2.24	2	1.190
I am fully aware of the services offered during antenatal care	2.25	1	1.407

Legend

1-1.79= Strong Disagreement, 1.80-2.59= Disagreement, 2.60-3.39 = moderate, 3.40-4.19= Agreement, 4.20-5.00=Strong Agreement.

Use and Uptake of ICT

Of the 83 respondents in Kampala, 62(74.4%) had mobile phones while 67(83.8%) of the 80 respondents in Jinja had mobile phones (see table 3-15) and of these, 90(55%) had smart phones (see table 3-16). Respondents 142(87%) expressed willingness to receive antenatal care information on their mobile phones (see table 3-17). In table 3-18 and 3-19, 90% of the respondents had never used any ICT to make decisions related to antenatal care, and of the remaining 10%, 8% had used a mobile phone while 2% had used a computer to enhance their decisions. 85% of the respondents expressed willingness to buy a smart phone should it appear to add value to antenatal care access and decision making (see table 3-20). In table 3-21, majority of the respondents strongly agreed on using mobile phones as a better way to communicate with care providers (μ=3.72) and community health workers (μ=4.10).

Table 3-15: Location * Do you have a mobile phone?

			Do you have a mobile phone?		
			Yes	No	Total
Location	Kampala	Count	62	21	83
		% within Location	74.7%	25.3%	100.0%
	Jinja	Count	67	13	80
		% within Location	83.8%	16.3%	100.0%
Total		Count	129	34	163
		% within Location	79.1%	20.9%	100.0%

Table 3-16: Is it a smart phone?

		Frequency	Valid Percent
Valid	Yes	90	55.2
	No	73	44.8
	Total	163	100.0
Missing	System	1	
Total		164	

Table 3-17: Would you be comfortable receiving information related to antenatal care on your phone

		Frequency	Valid Percent
Valid	Yes	142	87.7
	No	19	11.7
	11	1	.6
	Total	162	100.0
Missing	System	2	
Total		164	

Table 3-18: Do you use any ICT technology for decision making when utilising antenatal care services?

		Frequency	Valid Percent
Valid	Yes	15	9.2
	No	148	90.8
	Total	163	100.0
Missing	System	1	
Total		164	

Table 3-19: Please specify the ICT technology

		Frequency	Valid Percent
Valid	Mobile Phone	13	8.2
	Computer	3	1.9
	None	142	89.9
	Total	158	100.0
Missing	System	6	
Total		164	

Table 3-20: Would you buy a smart phone if you confirmed that it can add value during pregnancy?

		Frequency	Valid Percent
Valid	Yes	141	86.5
	No	22	13.5
	Total	163	100.0
Missing	System	1	
Total		164	

Table 3-21: The result of descriptive statistics on ICT uptake

	Mean	Mode	Std. Deviation
In my opinion a mobile phone would be a better way to communicate to medical workers	3.72	4	1.340
In my opinion a mobile phone would be a better way to communicate to community health workers	4.10	5	1.092

3.3 Discussion of Findings

Further analysis of the demographics indicated that women that had attended a much higher education level above secondary were less likely to bear more than three children (see table 3-1) than those with a low education level. Most mothers in both regions were multi-parous with more than three quarters having more than one child as demonstrated in table. 1-1. Results showed a very big child-bearing gap between these two regions with many respondents in Jinja giving birth between 18-25years contrary to their counterparts. This can be correlated with the low education levels in Jinja with many being primary school dropouts which may explain why

many were giving birth early. Emphasis on antenatal care awareness should be put on women in the age brackets of 18-35 since they bore more children than those above the age of 35 (see table 3-2).

Whereas women in Kampala considered midwives as their major source of information, in Jinja, peer mothers played this role more (see table 3-3). This can further explain why women in Jinja have less attendance of ANC and deliveries in hospitals as compared to those from Kampala. On average, women in Kampala were much more informed on their information needs than those in Jinja. Many singled out nutrition, danger signs, preeclampsia and lab test results information as key in enhancing their decisions (see table 3-4). Nutrition, danger signs, preeclampsia, obstetric emergency, weight, blood pressure and iron and folic intake are medical risk factors that fatally affect expectant mothers during pregnancy. Results (see table 3-4) indicate that mothers take information regarding to nutrition, preeclampsia and danger signs very importantly in their decision making because of the likely dangers that could adversely affect them and their unborn babies should such be neglected. Whereas results in table 3-4 indicate that mothers use this kind of information for decision making, table 3-14 shows that mothers were generally not well informed about the different medical risk factors which is a very bad indicator. A study conducted in Australia indicated that existing medical conditions like hypertension and diabetes are major risk factors for late entry to antenatal care (Guevarra et al. 2014).

On average, majority of the respondents in both regions did not have decision making autonomy. This supports previous study in Ghana that noted husbands, mother-in-laws and other family and community members being principal decision makers especially in cases of emergency obstetric care (Ganle. et al. 2015). The lack of knowledge which was cited in this survey as the major reason hindering women to participate in their decision making about antenatal care was also emphasized in the WHO (2015a) report as one of the reasons why women in the sub-Saharan region did not access antenatal care services.

It was clear from the survey that mothers were not well aware of the symptoms of danger signs expected during pregnancy. This can be supported by the study that was conducted by Kabakyenga, et al (2011) in south-western Uganda where only 19% of mothers had knowledge of 3 or more key danger signs during pregnancy, delivery and postpartum period. Lacking information about services offered and the importance of antenatal care leaves affects a mother's ability to make decisions to seek care.

Notably, in this survey, inadequate services offered in hospitals stands out as the second major hindrance to antenatal access which relates to Parliament of Uganda (2012) report that highlights the lack of medical staff, medical equipment and supplies, medicine and drugs in most government hospital. The non-attendance of antenatal care by especially mothers in Jinja could be attributed to the inability of mothers to make decisions to seek care and the lack of information about antenatal care, which was also reported in a similar study conducted in the Eastern part of Uganda (Tetui, et al. 2012). This can also further be related to other studies where women received limited information in their one-to-one antenatal care consultations (Pell et al. 2013).

Of those that went for antenatal care, at least more than 60% had attended more than twice in both regions, majority being from Kampala. However, not giving birth in hospital despite the fact that mothers attended antenatal care could be attributed to many factors like distance and lack of sensitization on the importance of delivery under a skilled birth attendant which were given as some of the reasons for not utilizing antenatal health services, a finding also highlighted by (Bowser and Hill, 2010; Mrisho, 2009). Subsequently, most mothers attended one antenatal care because they had fear for being refused to deliver from a hospital should they fail to have an antenatal care card, a finding which was highlighted in Ghana, Kenya and Malawi (Pell et al. 2013). The non-attendance of ANC by pregnant women has a psychological impact on mothers not giving birth in hospitals. Generally, mothers were not aware of the different services offered during antenatal care sessions.

Not giving birth in a hospital especially by women in Jinja can be attributable to the non-attendance of antenatal care or the lack of enough information about the importance of a skilled birth attendance. These findings relate to a study done in Ethiopia (Ayele, 2014) where institutional deliveries especially among rural women where far much less than antenatal care attendances. Most respondents on average lacked knowledge on issues pertaining to delivery yet majority of fatal complications happen shortly after delivery (Ayele, 2014). Similar studies conducted that focus on maternal health access have advocated for a need to sensitize women on antenatal care attendance and delivery under the care of a skilled birth attendant (Titaley et al. 2010).

Despite the fact that Kampala district is more urban than Jinja, the uptake of mobile phone usage in Jinja was significantly higher than that of Kampala though the figures in both regions are meaningfully good. This means that information can easily be disseminated among mothers

as many expressed readiness to buy mobile smart phones to receive antenatal care information should they find it important. There is need to educate the community at large with particular focus on mothers on the potential benefits of mobile phones in providing synergy, information sharing and decision making.

Qualitative Survey

What is described here is the qualitative assessment that was done with the expectant mothers as part of gathering information and getting a deeper understanding of the issues that affected expected mothers in order to corroborate results from the quantitative survey. To gain this deeper understanding, a focus group was organized by the researcher assisted by one research assistant. With the consent of the participants, all audio conversations were recorded which were later transcribed. Some of the responses were in *"Lusoga"* a local language spoken in the region but these responses were later translated in English. Excerpts from the sessions were mixed with the anecdotal narratives to give the reader a clear picture of what transpired. The identity of the participants was kept anonymous in this report to protect them.

Focus Group

One focus group was organized with 6 mothers in Jinja who were randomly selected from the sample that participated in the quantitative survey. The choice of Jinja over Kampala was the fact that Jinja is not as urban as Kampala and their community engagement with mothers is more than in Kampala. The focus group lasted one hour and an open-ended interview protocol that guided this discussion had four pertinent questions which included; 1) What challenges do you face during antenatal care? 2) What social, human, political or environmental factors influence your decision making? 3) Do you think a combination of midwives and CHW's would be a nice recipe to enhance antenatal care information access and decision making? 4) How best would you want to access antenatal care services?

When asked about the challenges that hindered their access to ANC while pregnant, expectant mothers described a number of them. Some of these challenges are summarized below:

Challenges

- Not having enough information to act on certain things
- Not getting the services they need in hospitals
- Sometimes midwives were unkind
- CHW take long to visit their homes yet also hospitals are far
- Forgetfulness
- House chores and having to attend to the family needs, money to go to hospitals are major problems.

Expectant mothers in this region noted that *information was a scarce resource.* All mothers acknowledged the existence of hospitals and community health workers, but they stressed that hospitals are *quite far* and yet even when they manage to get there it is *painful* to get to the care provider because of the *long queues.* Even when you get to see a midwife, some are exhausted, unkind and therefore give you less attentions. One mother offered a statement that was a representative of the comments of many of the participants:

'The hospitals we go to are government hospitals with a lot of integrated services but inaccessible. These hospitals are too congested with yet few care providers. So the thought of going to hospital and having to struggle for services that you end up not getting, forces many of us to stay at home and you use local medicine with the helper of an elder or friend. The only challenge is that most of the people we resort to, sometimes don't know how to handle certain situations and yet those who would have helped, are far, exhausted or unavailable.'

Participants noted that the CHW's helped them a lot and they are their main source of information however, they are engaged in other things and sometimes *take long to visit them.* This leaves many of the mothers who can't afford the transport costs to hospitals in a dilemma. Participants noted that they, in most cases needed information on how to take good care of their pregnancies, what they should desist from eating and doing, tips on a healthy lifestyle while

pregnant, conditions that are fatal for a mother and her unborn child, birth preparedness, blood pressure among others.

Most of them noted that they get some of this information on the radio, but one mother narrated that:

> *'Information on the radio or TV has been helpful only that it doesn't allow one to ask questions. So, even when you don't understand something, you cannot probe further. And also information on these media is very concise so whatever is communicated is very little in content.'*

Also, midwives schedule dates for ANC, however some mothers have busy schedules which involve house chores, farming and fetching water among others. Like many other participants, this mother voiced her views and stated that:

> *'During the times of rains, we give our gardens priority because we have to plant, since this is our major source of livelihood. So, sometimes we forget to go to hospitals and other times when you remember the bad experience you have been through in hospitals, sometimes you feel it's not worth it.'*

When asked about the social, human, political or environmental factors that influenced their decisions, mothers explained a couple of them which are summarized below:

Social, human, political or environmental factors
- *Mood*
- *Availability of finances*
- *Friends, spouse, CHW*
- *Weather*
- *Distance to hospital*
- *Kind of services.*

Some mothers (3 out of 6) noted that the prevailing mood determines their decision. Mother's noted that sometimes they wake up *tired, irritable* and *sickly*. Usually such circumstances made many postpone ANC visit. Money for transport and medicine, once not available, forced most mothers not to seek care because they described their residences to be "….*remote…and certain*

medicine are never free". One mother stated that "*…midwives keep referring us to go to pharmacies to buy medicine…"* yet also, the spouses who are their sources of finance sometimes do not have. Friends, spouses, CHW were key in influencing mothers to seek care. Other participants stressed that weather was another reason that influenced decisions. One mother whose sentiments corresponded with those of others explained that, "*when it is too hot, it is next to impossible to walk a distance of 5 or more kilometers",* and another mother interjected and emphasized that "*..harsh weather conditions like too much sun or rain, influence their decision to seek antenatal care services…* ". They emphasized that when this is coupled to the poor services, this leaves many no option but to seek other alternatives like *local herbalists, friends or peers.*

When asked about the role of CHW's and midwives in enhancing information access. Participants noted and appreciated the CHW's because many fail to go hospitals and wait for CHW who help them in solving a couple of problems. They acknowledged that CHW are very fundamental during pregnancy. In a statement that summed up the views of the different participants, one mother narrated that:

> *'CWH's are a backbone in our ANC practices so are the midwives. We know with certainty that their role is irreplaceable but maybe coordination between the two parties needs to be strengthened such that we also benefit in long run. We want to benefit from all of them because they complement each other.'*

However, participants noted that many times, mothers did not give elaborative information about certain things yet they think they are important. Mothers explained that *"midwives take our blood pressure but never tell us why they do, more so interpreting for us the results"*. So mothers agreed that doing it is because it's *standard procedure* otherwise, they would have opted out because they didn't know its importance.

Participants urged that midwives emphasized that they feed well during pregnancy for their *nourishment* and their babies. However, they noted that information on why, what and when they should feed is meagerly hinted on, and yet they thought it is *very vital* for their health. So they emphasized the need of getting this information either on *printed papers* or *to be sent on their mobile phones.*

All mothers agreed to the fact that they measured their weight when they go for antenatal care visits. However, their measurements which are usually done on an analog scale are displayed in kilograms. Mothers noted that they are usually given a *discrete figure* of their weight but not the BMI. One mother explained in her words that coincided with those of the other participants and said *"I have never seen a calculator with any midwife trying to compute my BMI. After weighing us, they read on the scale and note in the antenatal book."* But it should be noted that the standard measure for maternal weight is BMI, which is (Xkg/Ym^2) where X = body weight in KG and Y = height in meters. Hence, expectant mothers are not given the right information which affects the nature of decisions they make about weight. One mother was quoted to have said:

> *'When my weight reached 85KG, I was told that I was overweight and that I needed to reduce on what I was eating. The problem is I was not told the alternative foods to eat neither was I told the quantities I should consume.'*

Most mothers noted that nutrition is an important aspect during pregnancy for both the unborn baby and the mother, yet it is the least paid attention to during antenatal care sessions.

When asked on how best they would want to access and utilize antenatal care services. Expectant mother's responded as summarized below:

> *- Getting information as and when they need it*
> *- Enable accessing a CHW and midwife anytime*
> *- Fast case handling in case of a problem*
> *- Enable collaboration with care providers*
> *- Enable sharing of information.*

In their responses, mothers noted that they get little sometimes no information at all when they go for these routine checks. *"Midwives check you in a small room, press your stomach, ask you a few questions and they write in your book the next date of appointment."* Mothers urged that they want to get as abundant information as possible about different aspects of antenatal

care especially nutrition, danger signs, preeclampsia, delivery and newborn care among others. They urged that information needs to be given *"when you need it."* Mothers also iterated the need to access the CHW's and midwives as and when they need them. One mother stressed that *"…we should not wait for CHW to come knocking on our doors, but rather be in position to get them when we need them…"* Other participants stressed that they have conditions that are usually aggravated during pregnancy. For example one mother in her words that reflected the views of many noted that:

> *'Every pregnancy, I develop edema and preeclampsia. Sometimes, I just need a quick response from a care provider. But because we don't have a direct contact, many times I am left at the mercy of God. I would prefer to have a direct connection with at least my CHW to explain my problem especially when I am feeling bad such that I can get immediate help.'*

All mothers agreed unanimously to have a collaboration between the care providers because it's *"the only way we will save ourselves and our babies…"* emphasized by all of them. Sharing information using different avenues with *people that matter* in the antenatal care cycle is something that was seconded by all mothers.

3.4 Generic Understanding

Quantitative Survey

Low education level had a very strong bearing in determining the parity of women especially those in the rural areas. Antenatal care awareness through midwives and CHW's should be emphasized for the women and encourage delivering in hospitals as results pointed to over reliance on their peers. The over reliance on peers and CHW could be because of the long distances to hospitals and/or lack of transport making them the best information source alternative. However, staying away from hospitals means that these mothers are not getting adequate and useful information necessary to handle certain situations. This can be backed by the fact that more than half of the women in Jinja could not single out information that could be used for decision making, yet this information is critical and can affect the life of a mother and that of her unborn child. Hence, there's need to establish and strengthen the relationship between midwives to enable mothers access relevant information to enhance their antenatal care decisions.

Access to maternal health services is subverted by the lack of power by many women to make decisions especially those in rural areas. Lack of knowledge and experience, culture and financial constriction limits the ability of women to make decisions. Having little or no information about danger signs by most pregnant women is very risky which may lead to a mother dying or her unborn baby therefore collaborative information exchange among mothers, CHW's, midwives and their peers creates an avenue for information exchange and sharing. Antenatal care attendance is still very poor especially among women in rural areas. The rural-urban divide is still very big and this could further explain why many of these women do not give birth in hospitals. On average, antenatal care was poorly attended in Jinja unlike Kampala with an average attendance of 45% and 76% respectively. It is still evident that most women do not appreciate the importance of maternal health services like antenatal care, skilled birth care and emergency obstetric care which are key contributors to better maternal health outcomes.

Overall, there is lack of knowledge and information about services offered during antenatal care like identification and management of obstetric conditions such as danger signs, the use of skilled birth attendants, and enlightenment about healthy diet during and after pregnancy. Sensitizing and educating mothers coupled by strengthening community participation through a strong community health worker involvement can increase on accessibility and utilization of maternal health services. Despite the fact that majority of the respondents hadn't used any ICT technology for decision making, a large section of them had mobile phones, an indicator that mobile phone adoption for decision making could easily be embraced. Community health workers, midwives and peer mothers, family and friends play a big role in providing both antenatal information to mothers hence a need to strengthen this link to help mothers better their wellbeing in order to improve on maternal health outcome.

Qualitative Survey

From the qualitative survey, it can be confirmed that the lack of information, poor and sometimes inadequate services, and the lack of funds were some of the challenges that hindered many mothers from accessing care. A mother's decision to seek care was influenced by a number of factors like distance of the health facility, finances, mood and weather among others. And like other surveys, mothers acknowledged the important role of CHW's and midwives in antenatal care decision making practices.

In their quest for information, mothers need as much and accurate information as possible especially about preeclampsia, blood pressure, nutrition, birth plan, weight management and general antenatal care. It should be noted that mothers expressed their need to have different channels of information distribution such that they can get it promptly. The need to have a quick response strategy to deal with emergency cases was something many advocated for. Their emphasis on the need to share information with the different stakeholders coincides with the findings in the quantitative survey. It can be concluded from both surveys that mothers agitated for a strong collaboration with the care providers as a way of improving and enhancing antenatal care decisions to improve their maternal health outcomes.

3.5 Considerations of the ACS Design

As earlier discussed in section 3.4 (generic understanding), a number of ideas were generated to form part of the design that would create an environment where expectant mother's decisions would be enhanced. It was against these ideas that the following design considerations were proposed;

i) A design that could enable seamless information exchange for the purpose of enhancing expectant mother's decisions
ii) A design that could enable management of obstetric emergencies
iii) A design that could incorporate real-time training
iv) A design that could facilitate collaboration among CHW and midwives
v) A design that could enable mothers and peers within their social network share experiences, ideas and information to create a learning avenue
vi) A design that could enable capturing and storing blood pressure readings
vii) A design that could capture and store a mother's daily meal consumed for purposes of ascertaining that a proper diet is adhered to
viii) A design that could capture and store a mother's height and weight to compute and interpret BMI.

These considerations were presented to different stakeholders to ascertain that they reflect the requirements of the proposed design. Stakeholders were engaged to elicit, improve and fine-tune the design requirements. These stakeholders included expectant mothers, midwives and CHW's, PhD students of gynaecology, lecturers and experts in the field of maternal health and information systems. For each group of stakeholders, input about the design of the ACS was required and one question was used to guide the interaction. This question that guided these

sessions *was "How best can we improve on the design of the Antenatal Care Studio?"* The following were the reactions from each group, which are captured in form of a narrative.

Expectant Mothers

Ten expectant mothers were engaged in an interview that lasted approximately 30 minutes. When asked about what they wished to improve in the requirements and design and whether what was presented to them would help improve their antenatal care decisions, they offered the following;

Mothers expressed that when they go to hospitals and they measure their blood pressure, most often midwives just record but never offer an explanation of the results. One of the mothers, in her opinion that was similar to majority of the mothers suggested that:

> *'I am of a view that the design be incorporated with a function to capture, store and provide an analysis of the blood pressure measurement over a period of time. This could be offered in form of charts plus a description of the results every time they are entered in the system.'*

Other mothers also suggested the need of receiving information regarding antenatal care. They stressed that every time they go for antenatal care, their sessions are administered hurriedly because of the huge numbers therefore they don't get enough time to engage with the midwives. Other mothers suggested that the design should incorporate features that enable information exchange as a way of enhancing decision making. Most importantly, mothers noted that they needed an avenue that could offer reminders about antenatal care visits because most times they forgot. Because nutrition is an important aspect in pregnancy, mothers suggested the design to enable them capture and store what they have eaten, recommend what they should eat as *"this could help us maintain a balanced diet"* says one of the mothers.

To reap from the benefits of the studio, mothers suggested that having a self-paced function in the training suite could add value to the suite. As one of the participants voiced, *"Incorporating a self-paced service in the studio would enable those that can't afford the real-time sessions to get an opportunity to download the sessions and use them at their convenience."* Similarly, other members felt that mothers that can't afford the "data costs" of the real-time training would benefit from the self-paced versions though they don't get to enjoy the participative and interactive sessions that the real-time users enjoy.

Midwives and CHW's

An interview was conducted with 5 midwives where findings from exploration, research problem and objectives of the study were presented. Participants emphasized that the design should allow emergencies to be handled by a specific midwife or CHW for purposes of accountability. They emphasized that if emergency alerts are left to "*whom it may concern"* then chances of not being given priority are high. This was a concern that was voiced by majority of the participants. Similarly, they argued that expectant mothers should be attached directly to a midwife and a CHW to ease collaboration and communication. They also urged that the chief midwife allocates the CHW to the mother because they are aware of the cells each CHW serves. One of the midwife, whose opinion wasn't different from the rest of the midwives, elaborated that:

> *'CHW's work in specific geographical cells, that are unique to them. Each cell has a given number of households. Therefore, the design should put this into consideration, that the CHW can't work in more than one cell and a cell cannot have more than one CHW.'*

Information System Experts

People under this category needed to have a minimum of two years of experience in the field of information systems. A total of 4 experts participated in this session. These experts advised to incorporate a feature in the design that would allow expectant mothers to download and watch the training videos. Many of them emphasized that real-time sessions could be hard to attend by many because of data costs involved in live streaming. These experts also advocated for all emergencies to be appended with the location of the mother at the time of sending an emergency alert for ambulatory services to reach with ease (if any). For sustainability purposes, including hospital administrators as users in the design should be considered to monitor midwives. One of the experts emphasized in his statement that:

> *'If midwives are not closely monitored by their supervisors, then this would be a lost cause. The design should allow chief midwives to view pending, closed and referred cases.'*

Lecturers

In this session, 4 lecturers were involved and their concern about the design rotated around the following: They stated that the design should on top of capturing and storing daily meals consumed by expectant mothers provide a quantified analysis of nutritional value of meals consumed against the standard meals of expectant mothers. They further emphasized that for decision enhancement to take place, real-time engagement with the stakeholders was paramount.

PhD Students of Gynaecology

A total of 3 students from the school of gynaecology were interviewed and their suggestions revolved around the inclusion of a partograph in the design. An expert in the field of maternal health shared his sentiments, which were similar to those of the rest of the participants, he stated that:

> *'CHW's are an important link in maternal health value chain and yet their role has been contemptuously undermined. He emphasized that the design should permit CHW to train expectant mothers, be trained by midwives and refer problematic cases to hospitals.'*

Based on the interactions and a few iterations with the different stakeholders as discussed above, the design considerations were refined to echo the sentiments of the users of the ACS. Hence, the ACS design was refined to include the following:

i) Enable seamless information exchange with midwives and CHW's for the purpose of enhancing expectant mother's antenatal decisions.

ii) Enable a text message based service where expectant mothers can receive antenatal care information on their mobile phones.

iii) Enable the capturing and storing of blood pressure readings while providing an analysis and interpretation of the BP throughout a mother's antenatal period.

iv) Enable the capturing and storing of a mother's daily meal in-take, analyse and compare it against a standard meal of a pregnant woman.

v) Facilitate sending of alerts to mothers reminding them about antenatal care visits.

vi) All mothers should be attached to only one midwife and CHW but a midwife and CHW can have many expectant mothers assigned to him/her.

vii) Enable the management of emergencies where each emergency is directly tagged to either a midwife or CHW. The chief midwife should view the status of all emergencies.

viii) Enable all emergency cases reported to be appended with the geo-location of the sender.

ix) Incorporate both real-time and self-paced training services.

x) Facilitate collaboration among CHW and midwives in order to strengthen communication and enable sharing of information to help mothers augment antenatal care decisions.

xi) Enable mothers and peers within their social network share experiences, ideas and information.

CHAPTER 4 – ANTENATAL CARE STUDIO (ACS) DESIGN

From problem identification, this research traversed through exploration and abstraction leading to a generic understanding of the antenatal decision making challenges that expectant mothers face in Uganda. This chapter highlights the design of the ACS which is described using the "Ways-Of" framework. In this chapter, 4.1 describes the design overview, 4.2 explains the way of thinking, 4.3 presents the way of modelling, 4.4 illustrates the way of working and finally 4.5 demonstrates the way of governance.

4.1 Overview of the ACS

From the design considerations discussed in chapter three, figure 4-1 demonstrates the ACS design that was achieved after carefully putting together the viewpoints from the different stakeholders. These design considerations formed part of the services that were encapsulated in each suite. The figure below comprises five unique suites which include, the emergency suite, engagement suite, self-care suite, training suite and messaging suite. Keen and Sol (2008), define a suite as *"integrated sets of technology tools,"* combined together into a studio or platform to enrich decisions among users.

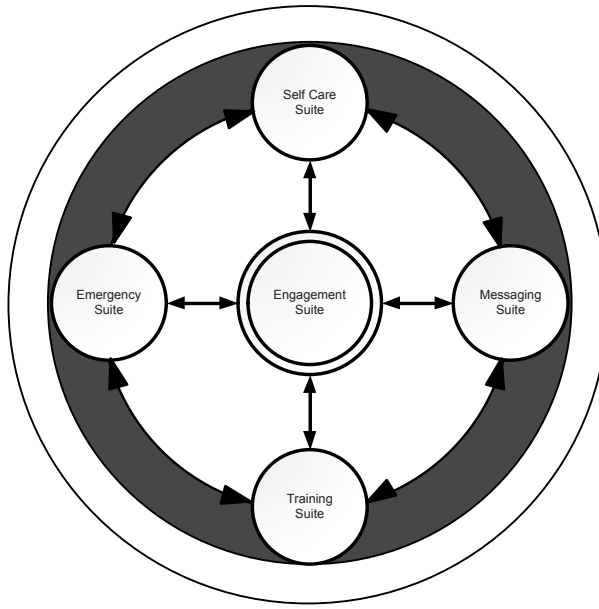

Figure 4-1: Overview of the ACS

Each of these suites is an integral component of the studio integrated together to enhance antenatal care decisions. The services of the ACS support collaboration and communication, emergency response, training, information sharing, analysis and interpretation. Within each service are recipes that assist different stakeholders to use the suites. Consequently, how to use the studio is governed by a set of guidelines and since CHW play an informatory and interventional role to expectant mothers in this studio environment, these guidelines help CHW to guide mothers on how to use the ACS. A description of the ACS design artefact was offered using Sol's (1988) "*Ways-Of"* framework which consists of four components, each addressing particular aspects of a methodology (De Vreede & Briggs, 2005; Seligmann, Wijers & Sol, 1989). These include*, the way of thinking, the way of modelling, the way of working* and the *way of governance* as demonstrated in figure 4-2. The choice of using this framework was based on the fact that a number of researchers (Tumwebaze, 2016; Katumba, 2016; Mirembe, 2015; Amiyo, 2012) successfully used it to describe facets of their design and it offers a chronological and logical sequence into the description of the design. This is helpful in understanding how the studio works, guidelines governing the use of the studio, underlying theories and models of the design artefact. Although the design is predominantly articulated by using Sol's *Ways-Of* framework, this research was also inspired by the design principles of the Product & Technology framework and MoTECH described in section 2.4 and 2.5 respectively.

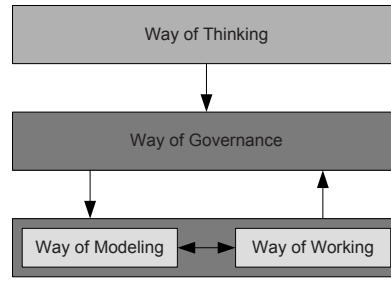

Figure 4-2: Framework to assess design methodologies (Source: Sol, 1988)

4.2 Way of Thinking

The *way of thinking* describes the underlying philosophies, theories and principles used in describing antenatal care decision making practices among expectant mothers. Theories explain how things are done, how organizations operate and how people interact in a certain way (Reeves, 2008). Decisions in antenatal care are complex and require multi-stakeholder

involvement. To achieve this, ACS was designed with recipes and guidelines to enable midwives and community health workers enhance the decision making practices of expectant mothers in Uganda. This was further realised using Keen and Sol's (2008) *decision enhancement services,* which is a combination of people, processes and technology working in unison and interactive environment with the purpose of augmenting antenatal care decisions. The choice of decision enhancement was based on the fact that there was no trace or evidence pointing to the applicability of decision enhancement in antenatal care in Uganda yet it has also been used by many researchers (Tumwebaze, 2016; Katumba, 2016; Mirembe, 2015; Aregu, 2014; Amiyo, 2012; Ssemalulu, 2012) to address decision making challenges in Uganda and East Africa at large. Decision enhancement focuses on decisions that matter (Keen and Sol, 2008) and a lot of decision making is based on stakeholder's intrinsic knowledge base. However, this tacit information source can be supported and enhanced by technology. The way of working of the antenatal care studio is explained using three constructs, *people, process and technology.*

The ***"People"*** make decisions based on their experience, judgment, intuition, skills and values (Keen and Sol, 2008). People whose decisions are to be enhanced in the ACS environment constitute pregnant women.

Expectant mothers are involved in daily decision making during the antenatal care period nevertheless, they face a number of challenges. It was discovered that the challenges facing mothers include but not limited to i) the lack of information, ii) the inability to interpret and use information iii) the broken link between the mothers and other players like the CHW and midwives who are a backbone in a mother's antenatal care period. The net effect of these problems is the inability of mothers to make timely and informed decisions. Nonetheless, it was discovered during exploration that stakeholder involvement and collaboration at community and hospital level was dysfunctional leaving mothers susceptible to inadequate access to antenatal care services. Hence, the ACS addresses this by providing an enabling environment where stakeholders can share information and offer advisory, promotive, preventive and lifesaving obstetric advice and care. The ACS enables stakeholders share insights, past experience and knowledge which is key in the decision making processes of expectant mothers. Peer mothers and other stakeholders have vast experience and skill regarding to antenatal care. ACS provides an avenue for sharing these experiences and once tested and proven effective by different actors, these experiences are documented and preserved by the administrators of the ACS such that a greater number of mothers can make use of them.

The ACS offers a spontaneous collaborative experience among stakeholders. However, these collaborations do not have structured times enabling actors to start interact spontaneously at any time. Ideas are visually exchanged in the ACS to enhance a shared understanding benefiting those whose decisions are to be enhanced. According to Gardner (2005), this collaboration leads to the creation of new knowledge as people work together to find solutions to complex problems. Furthermore, the ACS enables stakeholders and expectant mothers to mutually discover themselves as the synergy grows. This experience results into a consensus to take an agreed upon action. Additionally, the ACS can also be a good source of information for potential mothers, teenage girls, researchers, the ministries and NGO's advancing maternal health issues.

According to Trickett & Ryereson (2004), collaboration is best suited for solving wicked problems; problems that have imperfect or divergent solutions. Advertently, the ACS addresses this in an informative, pragmatic and timely manner.

A decision *"**Process**"* aims at making a real and substantial impact for the stakeholders (Keen and Sol, 2008). Decision making in antenatal care is a complex and ill-defined process. Talley (2011) states that a decision making process includes a series of activities that are all intermediate steps between thought and action. A woman's journey from conception, maternity and post-pregnancy period involves numerous decisions. The major focus of this study revolved around decision making processes of expectant mothers throughout their antenatal care period. Some of the antenatal care decision processes that mothers employed were iterative, parallel while others were sequential. Following this, it was noted during abstraction and exploration that expectant mothers did not have a structured decision making approach. They used a blend of heuristics, unbounded rationality decision making styles and sometimes their decisions were emotionally motivated. The aim of the ACS is to improve on decision process agility. A combination of speed, flexibility, coordination, collaboration and innovation improves decision process agility (Keen and Sol, 2008). The environment within which expectant mothers operate is volatile and uncertain and as posited by Keen and Sol (2008), collaboration is key in handling such complex situations because no one actor is a source of all information to make effective choices.

Urgency, agility, collaboration are essential elements in the decision enhancement environment (Keen and Sol, 2008) and since expectant mother's decisions are sometimes based on her thoughts and those of others leading her to take action, a studio-based design adopts such aspects. The rationale for using ACS, a decision enhancement studio was because previous

researchers (Mirembe, 2015; Aregu, 2014; Knol, 2013; Amiyo, 2012) adopted this concept and demonstrated a high degree of urgency and agility in the decision making process in their domain of research.

The "***Technology***" provides a backbone on which information systems operate. A technology supports an information system (Laudon & Laudon, 2011) which ideally is supposed to support people. The technology can provide multiple types and levels of support to both the people and the processes (Keen and Sol, 2008). The ACS runs on a web and mobile *technology* platform that enables *mothers* go through a series of steps in consultation with other *actors* to arrive to the best alternative solution in their *process* of decision making to improve on their antenatal condition. The technology embedded in the ACS design to enable communication include i) electronic meeting systems, ii) chat services, iii) short messaging services, iv) audio services, and v) video services. This is meant to increase both one-on-one and group interactions and communication in respect to enhancing decisions.

4.3 Way of Modelling

The way of modelling described the models used in the suites of the ACS. They provided information in a summarized yet comprehensive format to enhance decision making. To achieve this, five suites were identified. All the suites are embedded with recipes which guide (Keen and Sol, 2008) how the suites works. The use case diagram below demonstrates the overall picture of the studio setting.

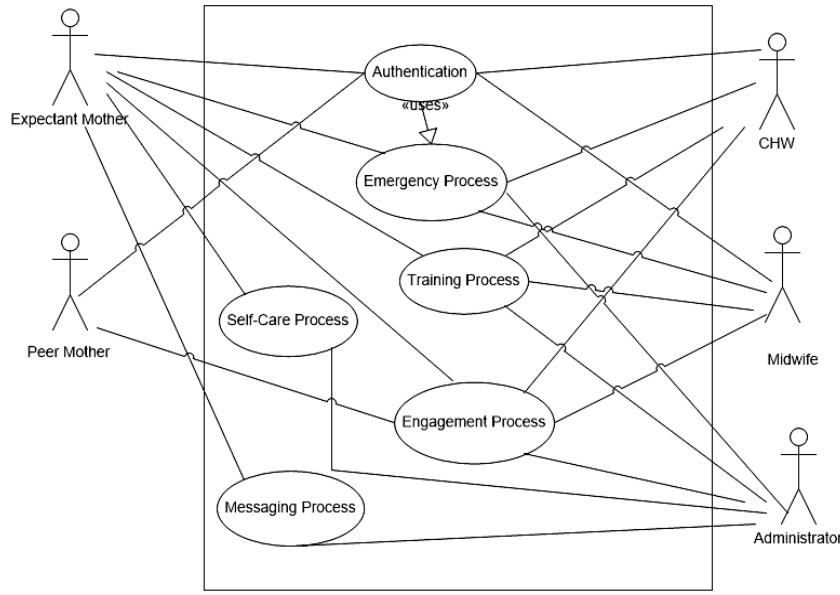

Figure 4-3: ACS Use Case Diagram

Figure 4-3 is a high level representation of the ACS focusing on actors and the different processes they interact with in the ACS. These processes were packaged as suites in the ACS design. The suites address antenatal care decision challenges among expectant mothers in Uganda and they were carefully designed to meet the specific needs of mothers. These suites integrated together in a studio environment require every user to first register before login can take place. However, all expectant and peer mothers are first authenticated by the midwife to limit misuse and abuse of the studio, therefore all registrations pend approval by the midwife. Apart from the expectant mother who interacts with all the suites, the CHW and midwife interact with only the training, emergency and engagement suites while the peer mother interacts with the engagement suite only. As earlier highlighted in table 4-1, a CHW's role in the studio largely focuses on i) facilitating training ii) exchanging information iii) offering guidance, advice and counselling to expectant mothers as a way of enhancing their decision making practices. Consequently, the midwife's role in the ACS range from i) supervising CHW, ii) providing information on antenatal care, basic and comprehensive emergency obstetric care, iii) training mothers on maternity care issues, iv) participating in collaborative sessions in the engagement suite. The peer mother's role in the ACS is to share insights and past experiences in collaborative sessions. All these roles are summarized in distinct suites as set of services summarized in the *table. 4-1*.

4.4 Way of Working

The *Way of Working* (WoW) describes the steps followed in using the ACS to enhance antenatal care decisions. This highlights the operation of the ACS which is hinged on; i) how information is accessed, used and managed, ii) how activities are coordinated, and lastly iii) how collaboration and communication between expectant mothers, CHW and midwives is handled. It articulates how the ACS can be explored by expectant mothers to access relevant information for enhancing antenatal care practices. Also, WoW demonstrates how the studio's capability as an invitational platform can be explored by expectant mothers to invite other stakeholders to collaborate, share insights and experiences. These stakeholders (community health workers, peer mothers and midwives) use the studio to facilitate and enhance the antenatal care decision making practices of a mother as described in table 4-1 below.

Table 4-1: Actors in the ACS and Their Roles

Actor	Role
Expectant Mother	Share experience and insight about their health
	Start, participate and end discussion or chat sessions in the engagement suite
	Make the ultimate decisions concerning antenatal care
	Inquire about any problem that may have arose and prompt for solutions from other studio actors
	Review any posted information on the timeline
	Attend virtual trainings organized by CHW and midwives
	Set reminders for ANC appointments
	Create and delete chat groups in the engagement suite
	Record, store and update meals in the database
	Record, store and update blood pressure measurements in the database
	Record, store and update weight measurements in the database
	Register and submit emergencies
Community Health Workers (CHW's)	Management and advice on treatment of minor illnesses.
	Increase awareness and self-sufficiency through a range of activities such as antenatal education
	Encourage utilization of health services and changes in behaviour directly related to health
	Provide information (curative, promotive and preventive information)

	Engage in real-time collaborative sessions
	Facilitate trainings
	Identifying the community's health needs and taking appropriate measures
	Mobilizing expectant mothers for health interventions such as sanitation and promoting health seeking behaviour
	Serving as the first link between the community and formal health provider
	Referring mothers to health facilities
	Virtual visits for mothers
	Follow-up on referred mothers and treatments prescribed
Midwife	Provide antenatal care with the aim of identifying high risk cases and referring them to hospital.
	Supervise CHW's especially in emergency case handling
	Providing information on antenatal care
	Training CHW's and mothers in maternal health related issues.
	Moderating information posted by peer mothers on the studio
	Participate in the engagement sessions
	Provide comprehensive information on maternal health (both basic and comprehensive emergency obstetric care)
Chief Midwife	Assign CHW of that health facility to pregnant women of that health facility
	Update the health facility profile she is registered to
	View number and profiles of midwives attached to that health facility
	View number and profiles of CHW attached to that health facility
	Assign midwives of that health facility to pregnant women of that health facility
	Assign midwives of that health facility to CHW of that health facility
	View number and profiles of pregnant women attached to that health facility
Peer Mother	Participate in the collaborative sessions
	Share ideas, insights and past experiences
Administrator	To ensure that the studio is available 24/7 and to correct any systems glitches

The roles that the different stakeholders engage in as described in table 1 above are embedded in the five suites of the ACS. The suites have dedicated services all aimed at improving synergy, collaboration and information exchange between the expectant mothers and the care providers. A full description of the suites and services is provided in table 4-2 below.

Table 4-2: A Description of Suites, Services and Requirements of the ACS

Suites	Sub-Suite/Function	Services
Emergency Suite	-Obstetric care	-Report obstetric emergencies
	-Health Facilities	-Document previous experience about obstetric emergencies
		-Facilitate referrals for mothers that need emergency obstetric care
		-Use mother's physical location to recommend the nearest health facility.
Self-Care Suite	-Weight Management	-Compute BMI and interpret of results.
	-Nutrition Management	-Summarize a mother's BMI in either tabular or graph format.
	-Pre-eclampsia Management	-Enable storing information about daily meals taken by an expectant mother.
		-Provide a summarised report on a mother's nutrition needs based on the nutrition information provided.
		-Provide an interface for capturing, processing and storing a mother's BP on a weekly basis
		-Summarize information into a graph to show mother's BP throughout her pregnancy.
		-Report signs and symptoms of preeclampsia to CHW or midwife for quick management
		-Share experiences about weight, nutrition or preeclampsia
Engagement Suite	-Collaboration -Communication	-Support real-time interaction between expectant mothers and ACS users.
		-Support collaboration in a participative and interactive environment
		-Enable sharing ideas, insights and past experiences
		-Facilitate both private and group chats among studio users

		-Support virtual meetings
Training Suite	-Real-time sessions -Self-paced sessions	-Facilitate real-time virtual training -Store and upload real-time training videos -Facilitate download of videos for self-paced training
Messaging Suite	-AC Reminder -Alerts	-Set reminders for antenatal care visits and other things -Support reminders for trainings -Send text messages to expectant mothers about emerging issues and general information about antenatal care.

The services stated in the table above gave a clear picture of how the suites work in the studio. The detailed description of the ACS suites is provided below.

Emergency Suite

The emergency suite enhances obstetric care decisions made by expectant mothers during times of emergency. This suite serves the purpose of enabling a pregnant woman respond to emergency cases in the shortest time possible. The emergency suite has two major services i.e. the emergency response service and the facilities service. The former aids a pregnant woman to respond to emergencies while the latter helps expectant mothers decide the best health facility to go to.

A woman experiencing an emergency initiates an alert by selecting the type of emergency and an alert, tagged with her physical location is sent to the CHW and midwife. Once the CHW or midwife receives the alert, engagement with the mother starts as a way of ascertaining the exact problem and offering quick first aid before is advised to seek professional help. If deemed fit by the expectant mother, she can engage with her peers in her social network to get insight from their past experiences.

In the same vein, a pregnant woman uses the facilities service to find the nearest hospital to visit. The choice of the health facility is based on proximity, services offered, advice from CHW or midwife, cost and ratings from other peers. The decisions enhanced in this process include, i) a decision to seek care from a health professional, and ii) a decision on a health facility to visit. These decisions are enhanced with the information provided by the suite and

the collaboration with the CHW, midwives and peer mothers. The services of the emergency suite also enhance other aspects of pregnant women's decisions like the kind of transport to use to get to the health centre, the kind of medical treatment to seek, the medical specialists needed, the kind of first aid and caretaker desired.

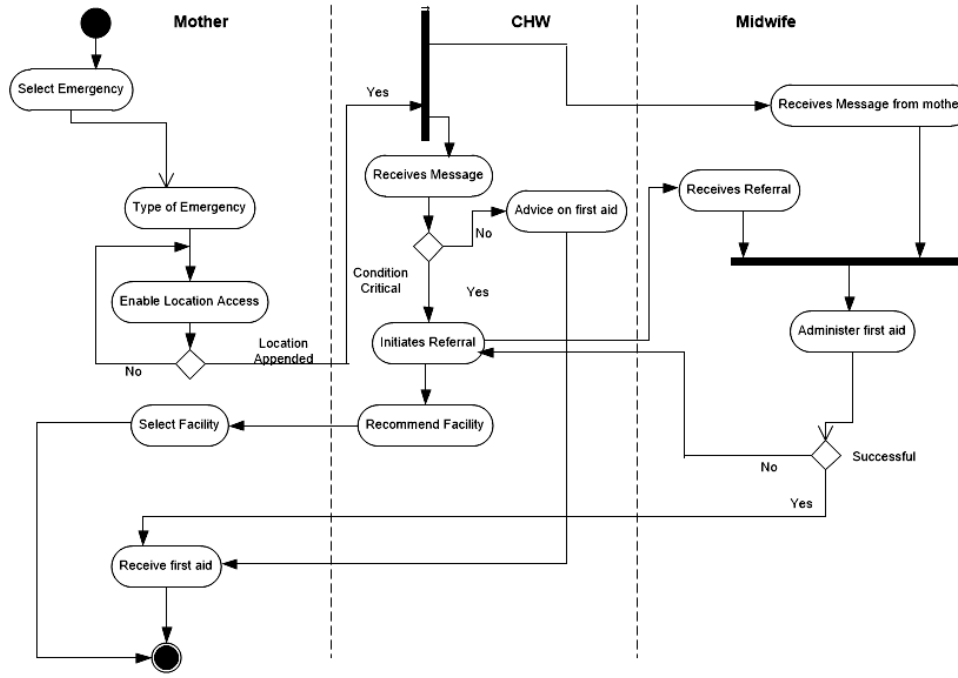

Figure 4-4: Activity Diagram of the Emergency Suite

Self-Care Suite

This suite deals with the day-to-day management of a mother's health during maternity period. This involves management of weight, nutrition and symptoms of preeclampsia. However, for mothers to make substantial decisions in regard to self-care, they need sufficient information which this suite seeks to address using a gamut of ICT tools such as text-based chat systems and electronic meeting systems. This suite is embedded with preeclampsia, nutrition and weight management sub-suites. The nutrition and weight management sub-suite supports pregnant women to maintain a healthy diet while monitoring their weight, and the preeclampsia sub-suite is centred on registering and reporting conditions symptomatic of preeclampsia.

Nutrition and Weight Management Sub-Suite

The sub-suite focuses on enhancing decisions regarding nutrition and weight. Key decision areas include; the choice of foods permissible to pregnant woman, quantity, when and how to feed, and the cost. The suite provides information about the different kinds of food suitable for the dietary needs of expectant mothers. Whilst, the suite provides an interface to enable expectant mothers avail information concerning what they have eaten and in what quantity in a particular day. The suite uses this information and compares it against the recommended standard meal of a pregnant woman. This analysis helps in identifying nutritional gaps which subsequently helps a mother in making the right decisions in regard to; what to eat, when, how, in what quantities which later influences her purchasing decisions on the different foods to buy.

Additionally, the suite also provides a service to enable a mother, on a weekly basis capture and store information concerning her weight and height to facilitate BMI computations for purposes of monitoring weight during pregnancy. Once BMI doesn't fall within the normal range, the mother uses this information to make various decisions which may range from seeking professional care to engaging in activities that may warrant a healthy life style. Where the nutrition and weight information provided by the suite is not sufficient enough to warranty decision making, the pregnant woman proceeds to collaborate with the peers, CHW's and midwives in the engagement suite to provide more insightful ideas to corroborate her decisions.

Preeclampsia Management

This suite is concerned with the day to day monitoring of a pregnant woman's occurrence of preeclampsia through watching conditions symptomatic of preeclampsia. Monitoring blood pressure in pregnant women involves watching for symptoms such as rapid weight gain, abdominal pain, severe headaches, sudden new swelling in the face, hands and eyes, reduced urine or no urine at all, blurry vision, dizziness and flashing lights. These symptoms are considered fatal by various medical experts (WHO, 2011b; Uzan, et al. 2011). The suite provides an interface for all these symptoms to facilitate easy capturing and reporting. The purpose of this suite therefore, is to enable expectant mothers report symptoms of preeclampsia as and when they occur. On reporting, an alert is sent to the midwife and the CHW, who, through the engagement suite interacts with the pregnant woman to ascertain the effect, recommend a first aid or referral to a health facility. Consequently, this suite provides a service where mothers record their BP throughout their pregnancy and a summary in form of a chart or table is generated to facilitate quick decision making. Also, a mother can document her

previous preeclampsia occurrences, which information is shared with other mothers who could consequently share ideas and insights related to the same.

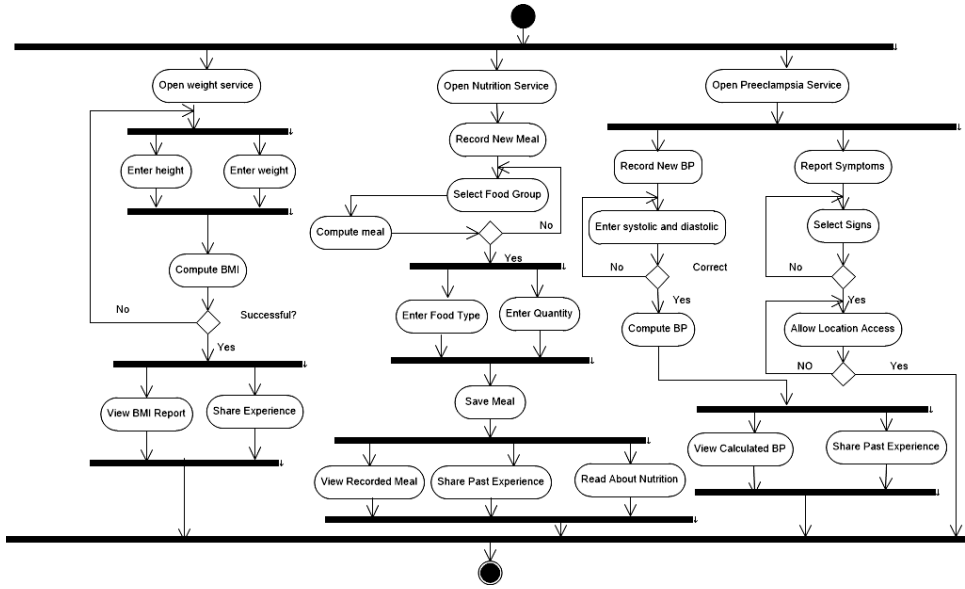

Figure 4-5: Activity diagram of the Self-Care Suite

Engagement Suite

It was observed during exploration that the working relationship between the mothers, CHW and midwife was weak and dysfunctional. Effective health care delivery depends on teamwork and collaboration and seamless communication (American College of Obstetricians and Gynaecologists, 2016; Hean and Smith, n.d). Keen and Sol (2008) stated that "people have partial knowledge and need collaboration with others who have additional knowledge". Hence, the purpose of the engagement suite is to revitalize the relationship between mothers, CHW and midwife while strengthening collaboration to improve decision making.

Unlike other suites, the engagement suite specifically focuses on collaboration and effective communication as major services to enable stakeholders interact, engage and share information. The engagement suite allows members to utilize the knowledge, share experiences and skills amongst themselves which helps in finding the most optimal solution to antenatal care problems. The engagement suite brings a mutual benefit to the pregnant mothers as well as the CHW and midwife as members share ideas and build a formidable social network. The ripple effect as a result of sharing ideas leads to self-improvement and decision enhancement

for pregnant women. This engagement suite promotes interactions among stakeholders and across all other processes in the ACS. This suite speeds up the way things are done by providing solutions to problems that would take a single mother a lot of time to solve. This is because several stakeholders employ unique viewpoints that allow generating numerous thoughts that a single mother may not be able to generate. The exchange of information in this suite is virtual amongst a group but for problems that require high levels of confidentiality, one-on-one sessions are provided. Tools employed in the engagement suite include electronic meeting system and text based chat systems.

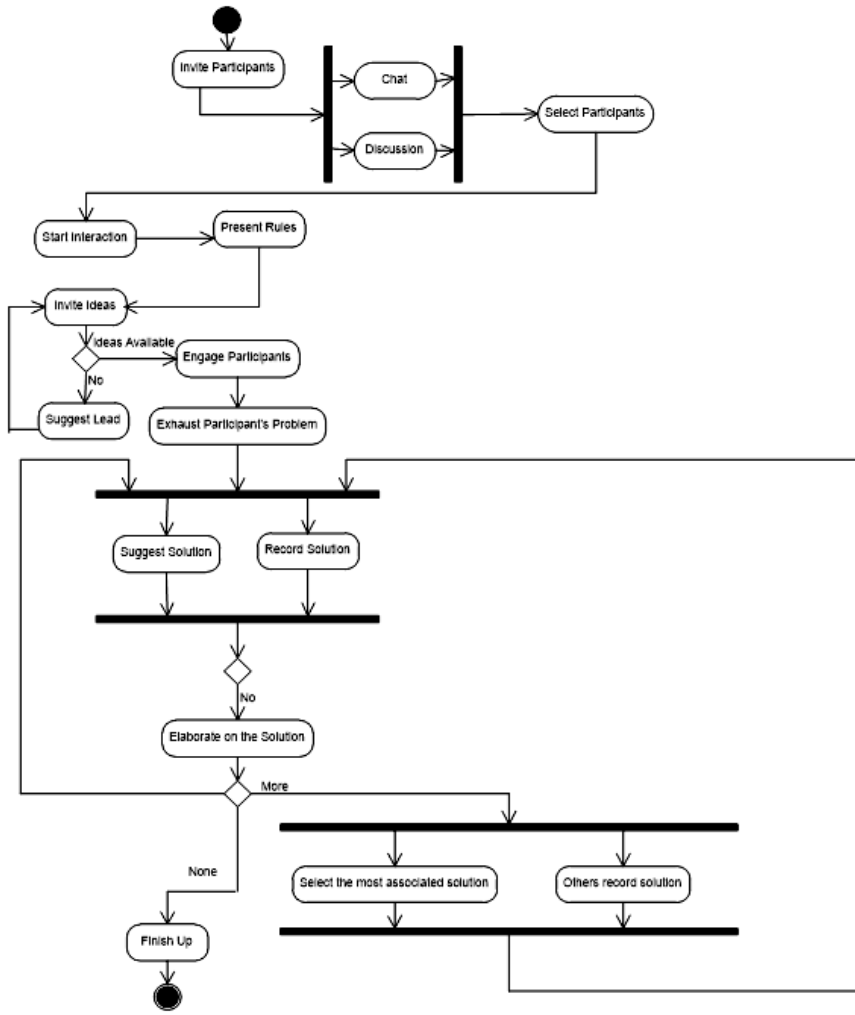

Figure 4-6: Activity Diagram of the Engagement Suite

Training Suite

This suite is an avenue for providing skills to pregnant women making the ACS partially a learning studio. According to Keen and Sol (2008), a learning studio is defined as "a platform intended to help participants build new understanding that leads to a new sense of options and processes, suites therein becoming vehicles for training". It was noted during exploration that pregnant women found it hard to go to designated places for antenatal care largely because of the distance, cost and infrastructural issues.

The training suite is an avenue were specific topics in maternity and antenatal care such as breastfeeding, birth planning, nutrition, neonatal care among others can be discussed. A training to be conducted will require prior registration by mothers to enable purposeful planning. CHW and midwives conduct trainings in antenatal and maternity care looking at both basic and comprehensive obstetric care. Antenatal care decisions enhanced include the choice of a birthing method, identification of antenatal care health needs, identifying and managing obstetric emergencies or danger signs among others.

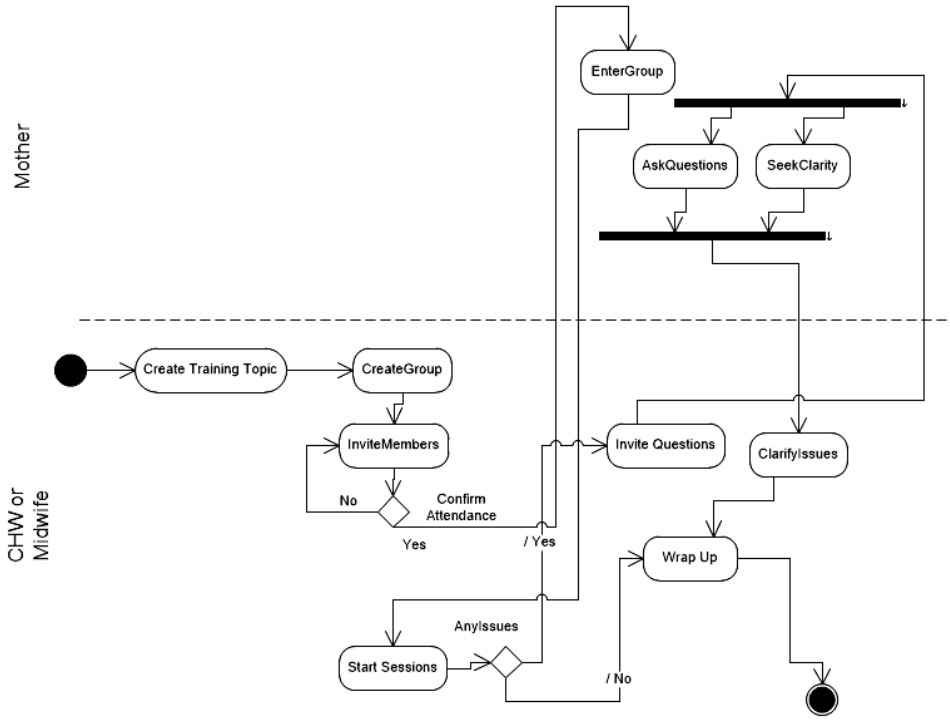

Figure 4-7: Activity Diagram of the Training Suite

Messaging Suite

This suite was designed to enable expectant mothers on a weekly basis, receive information in form of text messages on issues concerning antenatal care. Since the ACS is an internet enabled platform, some mothers have limited access because of infrastructural issues and data/internet costs. Hence, this service enables every woman registered with the ACS receive text messages. Information in these text messages was structured both in English and Luganda (the most commonly spoken language in the region) in order to communicate to a wider audience.

Content structured in these text messages include information on new-born care, hygiene, nutrition and general issues in antenatal care. The administrator of the ACS broadcasts messages to all expectant mothers registered with the studio.

Also, the suite houses a reminder service which requires a mother to specify the date and time of the event. This is to help mothers set reminders for their antenatal care appointments to avoid forgetting which was found to be a common problem for many. These events can be edited and deleted.

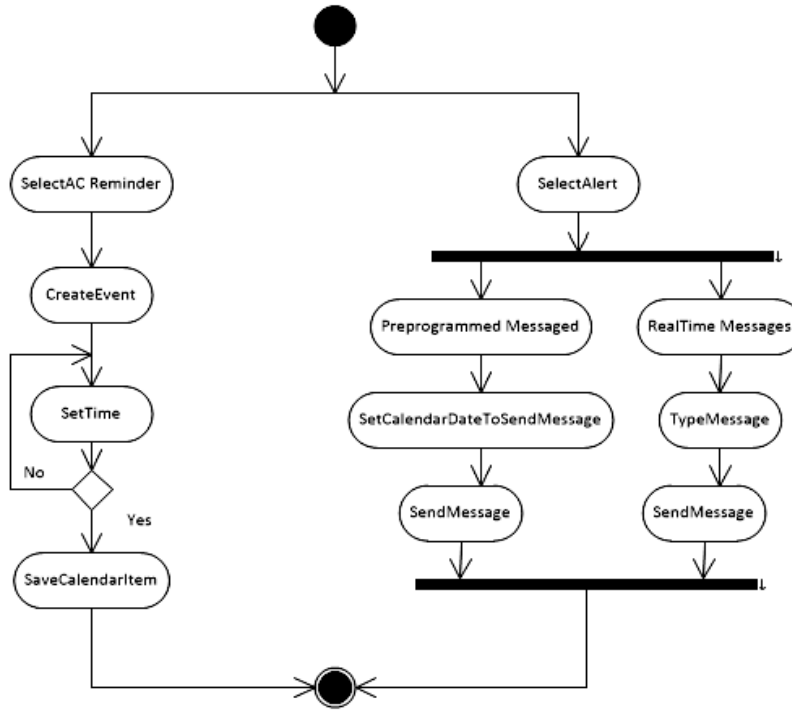

Figure 4-8: Activity Diagram of a Messaging Suite

Antenatal care decisions among expectant mothers involves collaboration among multiple stakeholders, the sequence diagram below demonstrates how objects/actors operate with one another overtime and in what order. This sequence diagram (*see fig. 4-9*) depicts the objects involved in a given scenario and the order of messages exchanged between the actors needed to execute the functionality of the scenario.

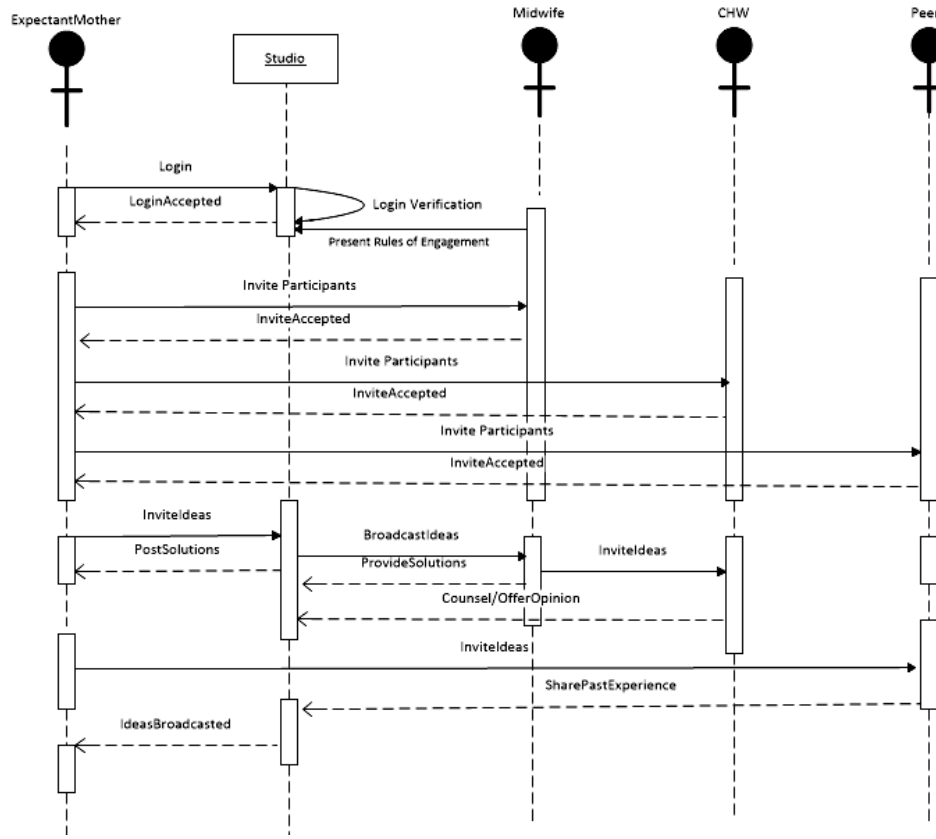

Figure 4-9: Sequence Diagram of the ACS

The suites discussed in the *way of working* have recipes that demonstrate how these suites work. Recipes are proven, repeatable, adaptive and codified procedures that are transferrable across organizations (Keen and Sol, 2008). *Table. 4-3* lists recipes of each suite in the ACS.

4.5 Way of Governance

The *way of governance* describes the management aspects (Sol, 1988) surrounding the use of the ACS platform. Special to note are the guidelines that control the engagement process, information accessibility, use and conduct in the training sessions. The following guidelines should be reflected on if decisions are to be enhanced in a multi-stakeholder environment;

General Guidelines

All users of the ACS should adhere to the principles of registration before access to the studio is granted. For expectant mothers, they are mandatorily required to provide their LMP before

registration is complete. The midwives are required to provide the health facility they are attached to and the CHW are supposed to provide the cells they manage in their community and the health facility they report to.

After registration, approval to access and use the studio by all expectant mothers is done by the chief midwife of that health facility that the mother is attached to. Therefore after registration, mothers wait for that approval, otherwise they cannot use the studio. This is done to minimise on the abuse and misuse of the system.

No one user of the studio can have the same username or password. This is to enforce security and integrity of the data plus build confidence and trust among the different users of the studio. This was implemented using both the entity and referential integrity rules that enforces non-duplication of data in the database using primary and foreign keys.

Once the above is adhered to, then information creation, storage and dissemination among different users of the studio can take place in a secure and reliable environment.

Participants in the ACS are entitled to their opinions especially in the engagement suite. However, all submissions are categorized and scaled using the Likert scale of 1-5 where 5 represents the most favourable and 1 represents the least favourable. This scaling is meant to help in consensus building especially on unstructured issues that require use of reasoning, intuition and expert judgment.

Users of the ACS should have the required skills to use the tool. This will be realized through the trainings that will be conducted in order for the users to appreciate the tool's capabilities. These trainings enhance user involvement and builds commitment to use the tool. In their interventional role, CHW will train mothers on the use of the ACS

Information specifically on weight and nutrition management in the self-care suite will be shared with the CHW and midwife through the engagement suite to offer professional advice for decision making purposes for expectant mothers.

It should be noted that an environment where many actors are engaged in trying to arrive at a solution, an idea or decision, if not well guided, may yield no fruit. Without procedures, group interactions may find it hard to stay focused, time may not be used wisely and the likelihood of making choices without due assessment is high ("Solving problems," 2005, p.158). Therefore, in order to realize value from this interaction, the above stated guidelines are recommended to guide the actors in the ACS environment.

Specific guideline governing the use of suites in the studio

These specific guidelines highlight a step by step process entailed in the utilization of different suites in the studio. These procedures guide decisions and criteria regarding use, dissemination and management information and activities in the ACS. The table 4-3 below provides descriptive guidelines of each suite in the studio.

Table 4-3: Recipes and Guidelines for ACS

Suites	Specific Guidelines
1. Engagement Suite	**How collaborative decision making is enhanced**
	1.1 All participants should be registered members of the ACS
	1.2 After registration, participants are provided with login details
	1.3 Presenting the issue(s) to be discussed
	1.4 Issues to be discussed will categorically be arranged to eliminate confusion and one subject discussed at a time.
	1.5 Presenting the rules and procedures to govern the session
	1.6 Every session has a moderator to guide the engagement session
	1.7 Inviting ideas from participants
	1.8 Ensure impartiality in the discussion
	1.9 Give leads to demystify complicated ideas
	1.10 Engage members to explicitly explain and provide meaning to their ideas
	1.11 Sessions are time bound
	1.12 Exhaust ideas from participants by continuously probing them
	1.13 Peer mothers will share their experiences in regard to the subject
	1.14 Ideas from peer mothers are moderated by midwife and CHW to ascertain their authenticity before being uploaded to the information suite repository
	1.15 Issue raised not pertaining to the subject discussed are discarded
	1.16 If suggestions aren't satisfactory enough, further idea generation is conducted

	1.17 Each idea is evaluated by the experts that is, the midwife and CHW 1.18 Ideas evaluated will be ranked or rated based on importance and value 1.19 Ideas ranked will use a scale of 1-5, 1 representing the least valued idea and 5 representing a highly ranked idea 1.20 Members will commit to the idea(s) selected through building consensus 1.21 Session closes officially and no further ideas discussed at this moment on.
2. Self-Care Suite	**How will services within the self-care can be utilised?**
	Weight Management **2.1 Calculating BMI** 2.1.1 Log into the studio 2.1.2 User opens weight management service 2.1.3 Mother provides her weight (kgs) and height (cms) 2.1.4 Submit information 2.1.5 Share best and worst experiences **2.2 Nutrition Management** 2.2.1 Log into the studio 2.2.2 User opens nutrition management service 2.2.3 Select food group to record 2.2.4 Provide types of food and quantity consumed 2.2.5 Save meal to the database 2.2.6 Share best and worst experiences **2.3 Preeclampsia Management** 2.3.1 Log into the studio 2.3.2 User opens preeclampsia management service 2.3.3 Provide systolic and diastolic reading 2.3.4 Comments from doctor recorded 2.3.5 Save BP to the database

	Reporting signs and symptoms of preeclampsia
	2.3.6 Open preeclampsia signs and symptoms service
	2.3.7 Select symptom(s)
	2.3.8 Submits information
	2.3.9 Share best and worst experiences
3. Training Suite	**How will training be conducted?**
	3.1 Date of training set which automatically appears in every expectant mothers *AC reminder*
	3.2 Communication of a training to take place is done through text messages
	3.3 Member to attend a training first register for planning purposes
	3.4 Members confirm their attendance
	3.5 Topics of training are posted before training day
	3.6 A trainer is communicated to the members
	3.7 Moderator of a training sessions is identified
	3.8 Trainings are categorized between those meant for mothers and CHW's
	3.9 Trainings are time bound
	3.10 Sessions begin and topic to be discussed is presented
	3.11 Session is open for questions
	3.12 Ideas are demystified for members
	3.13 Training closed
	3.14 Information uploaded for self-paced training
4. Emergency Suite	**How will emergencies be handled?**
	4.1 Obstetric Care
	4.1.1 Log into the studio
	4.1.2 Select danger signs experienced
	4.1.3 Enable *" allow location"* service
	4.1.4 User submits information

	4.1.5 Share best and worst experiences
	4.2 Facilities Service
	4.2.1 Open *"My facilities"* service
	4.2.2 Open continue tab
	4.2.3 Enable *" allow location"* service
	4.2.4 Submit information
	4.2.5 Select most convenient health facility from the list
	4.2.6 Share best and worst experiences
5. Messaging Suite	**How will messaging and reminders be done?**
	5.1 Alert Service
	5.1.1 Log into the studio
	5.1.2 Select *"alert"* services
	5.1.3 Views/delete messages
	5.2 AC Reminder Service
	5.2.1 Log into the studio
	5.2.2 Select *"AC reminder"*
	5.2.3 Set date and time of event
	5.2.4 Create event
	5.2.5 Save calendar item

CHAPTER 5 – INSTANTIATION OF THE ANTENATAL CARE STUDIO

This chapter describes the implementation of the antenatal care studio (ACS). Major focus is zoomed in on the implementation of the design, the output in chapter 4, which is a reflection of expectant mothers' requirements. This chapter is divided into the following sections; section 5.1 discusses instantiation consideration, section 5.2 ACS description, 5.3 presents data integrity and authenticity.

5.1 Instantiation Consideration

Design science research involves the creation of new knowledge through design of novel or innovative artefacts (Vaishnavi & Kuechler, 2008; Hevner et al. 2004; March and Smith, 1995; Nunamaker et al. 1990). The generic understanding offered a conceptual prescription which was explicitly demonstrated as the *ACS Design* described in chapter four.

The current mHealth applications in Uganda are standalones and fragmented providing services in isolation (Kearney, 2012; William, 2013). Against this background, the ACS was hinged on the Service Oriented Architecture (SOA) which essentially is a collection of services communicating to each other to enable pregnant women and other users utilise services such as user validation, producing of data, performing basic analytical functions among others. Service Oriented Architecture is a loosely coupled architecture designed to meet the needs of the users (Linthicum, 2017). ACS instantiation aims at a collaborative, synergetic and facilitative environment that brings together expectant mothers as *decision makers* and other stakeholders like midwives and CHW as *decision enablers*.

Programming Languages

The ACS was implemented using PHP hypertext processor, JavaScript, Cascading Style Sheets (CSS), Hypertext Markup Language (HTML) and MySQL, programs that have been recommended and used by several developers (Halvorsen, 2016; Schifreen, 2009). All these platforms had something unique they brought to the development environment. The choice of using PHP was based on its ability to interact with the database bringing pages to life in the browser and enables user validation coupled with its ability to work with modern frameworks. JavaScript was used because it enabled users of the ACS make requests through the browser by providing highly responsive interfaces with dynamic functionality that can load content into the document as and when the user needs it. Cascading Style Sheet (CSS) was used because

the web pages load easily hence users use less bandwidth. Most importantly it's compatible with all browsers and works well with HTML. HTML is user-friendly, supported by every browser and doesn't involve strain on the server. MySQL was a database management system used because it has solid data security layers, can handle huge sums of data and supports PHP.

Additionally, ACS uses Laravel, a PHP framework which follows the Model-View-Controller (MVC) architectural pattern. Suites were modelled using data from different expectant mothers and stakeholders which was later processed and graphically presented. ACS runs on this model-view-controller framework with each suite having its own model, controller and view. The controller contains all functions of actions that are used in the suite. The controller makes calls to functions in the suite model and/or other models by pointing to a specific function as invoked by the user. When this controller accesses the data stored in the suite model through a given function, it analyses the data to the specific suite view and the view displays the data forwarded by the controller from the model. The ACS has multiple views that display different output for the same information; for example information about weight can be displayed in form of a bar chart or in a tabular format. The models in the MVC architectural framework picks data from the database that is later displayed by the suite views. The controller is the only class that manipulates the model (ACS database). When the users of the ACS invoke an action or series of actions, the controller modifies the model, and after the model has been updated, the controller notifies the view (suite) that an update needs to be done. It is at this point that the suite requests the data from the model.

ACS uses the eloquent ORM, an object-relational mapper which allows to use the database objects, relationships and expressive syntax. There resides a utility on the ACS that processes data. Processing data involves creating new data, updating existing data, retrieving existing data and removing data from the ACS. Data is processed by mainly 5 components namely; the emergency suite, engagement suite, self-care suite, training suite and messaging suite as demonstrated in figure 5-1.

5.2 Antenatal Care Studio Description

This section provides a detailed description of the Antenatal Care Studio. Specific attention is on the product documentation that explicitly explains how the ACS instance works. Several authors (Chaudhary, 2014; Kipyegen & Korir; 2013; Forward, 2002) allude to the fact that system's documentation provides a basis to maintain the system; communicate information about the software system itself; more effective testing, corrections and improvements. It was

against this background that the studio was documented. ACS is a mobile website that was designed for desktop to tablet and handheld smartphone users. For the handheld devices, access to the internet is strictly through WiFi, 3G or 4G networks. The rationale for using a mobile website was based on the fact that it's mobile friendly content to the widest possible audience. Also, mobile websites are accessible to users via a browser across a range of devices such as iPhone, android and compatible across different types of mobile devices (Summerfield, 2017).

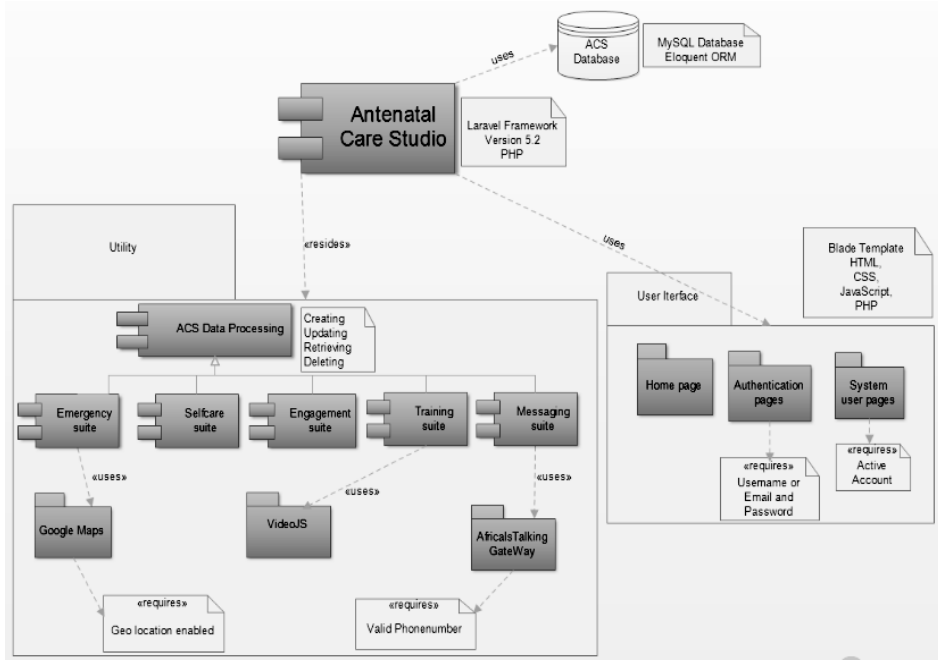

Figure 5-1: Component Diagram for the ACS

The ACS is hosted under the domain http://matpostcare.com which allows the different users to first register before access to the system is authorized. All registered users are first approved by the systems administrator before log-in in order to eliminate unscrupulous people from misusing and abusing the system. The studio runs on roles whereby each user role accesses different interfaces based on what they are meant to do. The roles include; expectant mothers, peers, community health workers, midwives and chief midwife. Each of the roles interacts with the studio differently via different access rights. The chief midwife is in charge of the health facility account.

All expectant mothers are assigned to either a CHW and/or a midwife of that health facility. There are two ways in which a pregnant woman is assigned a health worker i) if she is assigned

to a midwife, she cannot be attached to a CHW. The system generates a midwife-pregnant woman relationship ii) if she is assigned to a CHW, the CHW must then be assigned to a midwife because all CHW report to midwives. The system automatically generates a midwife-CHW-pregnant woman relationship. Important to note is that assignments happen between individuals of the same health center, that is, the CHW of Walukuba Health Centre is allocated a midwife of the same facility and pregnant women who are attached to the same. This was solely done for security and accountability purposes.

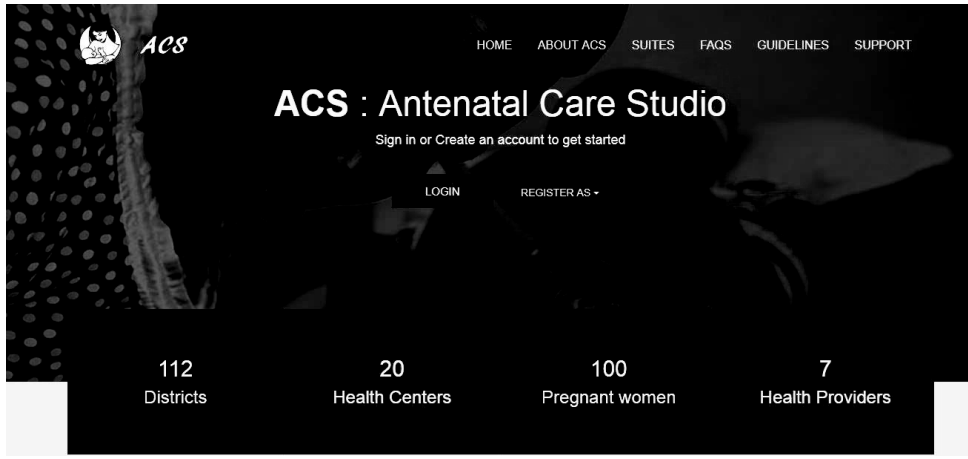

Figure 5-2: The Antenatal Care Studio Home Page

For every combination of district, health center, pregnant woman and health provider that's added to the system, an aggregate is computed in the black boxes as demonstrated in figure 5-2. All first time users of the studio are required to register their details but most importantly a telephone number, the facility a pregnant woman is attached to, username and password are mandatory fields. A telephone number was required for pregnant women because from time to time, they received messages reminding them to go for ANC and also general information about pregnancy was shared. All pregnant women on registration were required to provide their *first day of their last menstrual cycle* to help compute their *expected date of delivery*. On signing up, a user only accessed the studio after the administrator's approval, who, on registration of any user received a notification to approve a registered user. A user could use a preferred username or email address and a password to login.

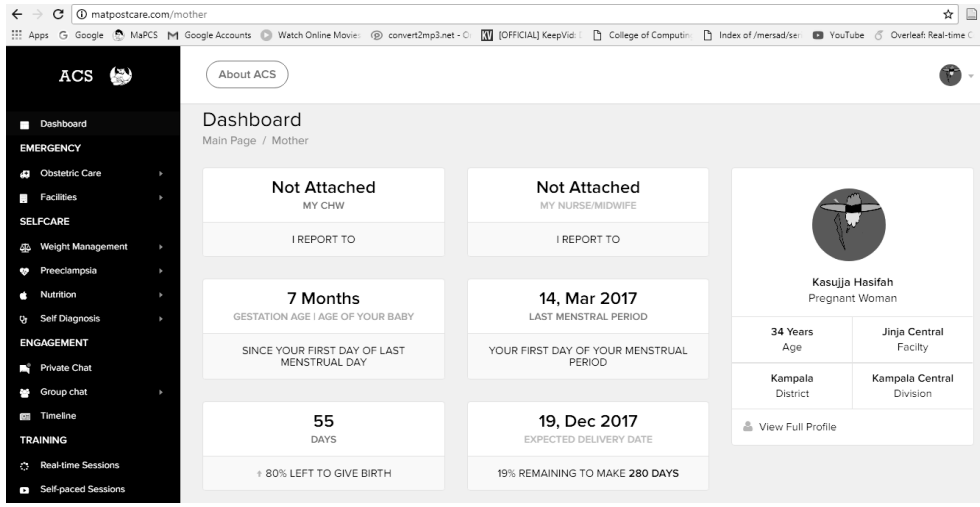

Figure 5-3: The Dashboard

As illustrated in figure 5-3, on login, a dash board with summarized information pertaining to a pregnant woman is displayed. This information includes the gestation period, days to delivery and expected date of delivery which is all computed from the *first day of the last menstrual cycle* provided during registration. Furthermore, information pertaining to a midwife or CHW that a pregnant woman is attached to, is also provided on the dash board.

The studio is comprised of five suites namely; emergency, self-care, engagement, training, and messaging suite. These suites are viewable on the left hand side, vertical to the dashboard information upon login by a pregnant woman. The light blue color forming the background of each sub-suite and service tab upon *"passing a mouse over"* indicates that the service is active, clickable and usable. When a user clicks on any services within a suite, a new page is loaded that displays the content of that particular service. Each suite was designed to ensure that instantiation consideration are taken care of and that the services therein are easily accessible and navigable by the users. The section below provides a detailed and explicit description of the ACS suites and services.

Emergency Suite

Emergencies may crop up anytime anywhere and pregnant women are not an exception to these occurrences. Hence, the emergency suite was instantiated for pregnant women who might get stuck in an unpleasant or unprecedented situation. Emergency situations that were considered fatal and could lead to the demise of a mother and/or her unborn child were vaginal bleeding,

severe abdominal pain, high fever, loss of consciousness, severe headache, no fetal movement, persistent vomiting, painful urination, visual disturbances, swelling of the fingers, face and eyes. To address this, the emergency suite was packaged with two main services; the facilities and obstetric care services which are visible on clicking the main menu icon represented as three horizontal grey dashed lines on the left hand side of the page.

The **"Obstetric care"** service was intended to provide care to the pregnant woman should an emergency occur. This involves offering first-aid advisory services to a pregnant woman while preparing to go to a health facility. When a user clicks on the obstetric care tab, more services (send request, previous requests and danger signs) in form of tabs are displayed.

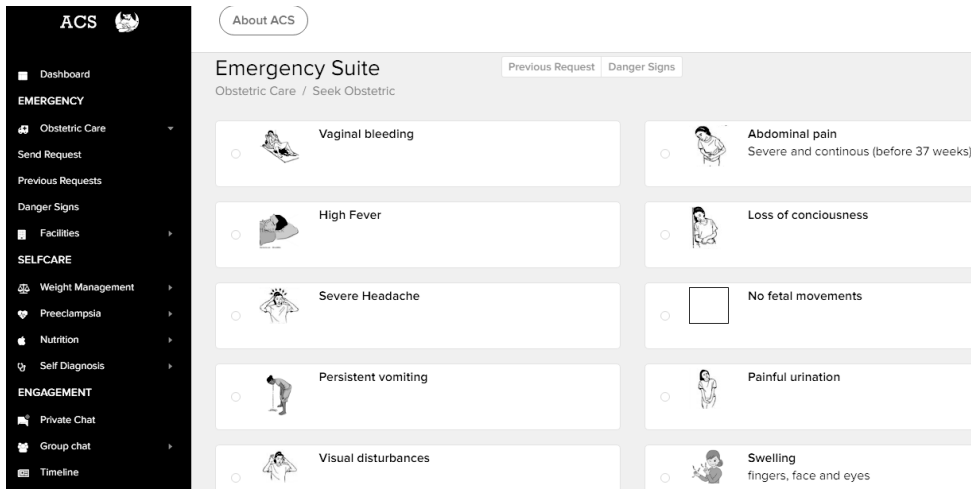

Figure 5-4: Emergency Suite Services

A pregnant woman experiencing any of the above sign (s) clicks on the *send request* tab that displays a list of emergency cases as illustrated in figure 5-4. A mother selects one or more options depending on what she is experiencing and clicks the submit button at the bottom of the page. This message is directly relayed to the community health worker and the midwife that the woman is attached to. Most importantly, the message sent picks the current physical location of the mother and if there's any help in form of ambulatory services, then the location is to pick the mother from is known. Additionally, the message sent to the midwife or CHW has a time and date stamp to allow health providers monitor when the incident occurred. To cater for women with reading difficulties, visuals or images where appended against the text for easy identification of emergency cases. A woman facing any form of difficulty can make a quick decision to inform the health providers who in turn provide information through the

engagement suite on how best the woman can handle the situation while preparing to go to the health facility.

The *previous requests* tab shows a summary of cases that a mother has experienced before and the *danger signs* tab provides basic information about the possible warning signs and their causes which information is vital making decisions to seek care should any of the symptoms occur.

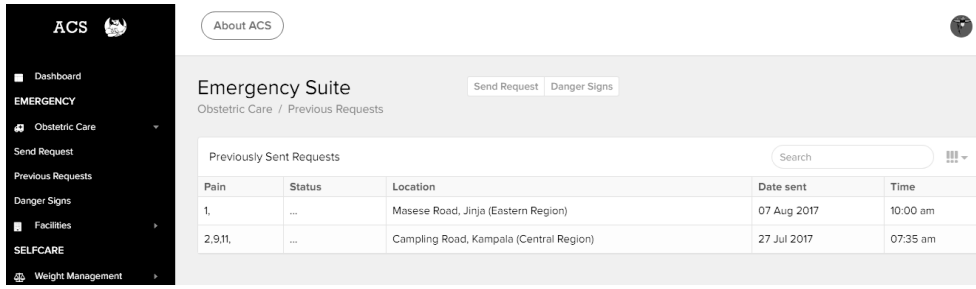

Figure 5-5: Emergency Suite "Previous Sent Requests" Services

The **"Facilities"** service was specifically instantiated to enhance a pregnant woman's decision on the health facility to seek care from. The emergency suite uses the Google Maps API to locate health facilities. The API requires geo-location enabled on the device in use, which later captures and transforms geographical coordinates into a visualization that is used for decision making. Within the API is the vector data model that uses points and their associated X,Y coordinates pairs to represent the vertices of the health facilities.

On clicking the facilities tab, four options are displayed. The "*my facility"* tab which displays information about the type, services and the location of the mother's hospital she's attached to; *"all facilities"* displays the health facilities that were used in this study; *"share past experience"* lets a mother document or share information about the kind of service received at a given health facility, which information is posted on her timeline and visible to other pregnant women hence could be helpful in the choice of a health facility by other mothers; and the *"nearby facilities"* service shows the hospitals that are close to the mother's current physical location should a mother report an emergency. This service enables a mother to make quick decisions on which health facility to seek medical attention from based on proximity.

The process flow of the emergency suite begins when the pregnant woman experiencing an emergency initiates an obstetric care request. The CHW attached to that pregnant woman receives the request as an alert and MUST take an immediate action. The midwife is able to

view, respond and monitor all requests of pregnant women attached to her. The chief midwife views all requests sent by pregnant women to the health center she manages. However, if the pregnant women is not attached to any CHW or midwife, the request is received by only the chief midwife who must act on it. If the pregnant woman is not attached to a CHW but attached to a midwife, then the requests is received and must be acted upon by the midwife. Unlike the rest, the pregnant woman can view nearby health centres.

Self-Care Suite

The self-care suite enhances decisions relating to care given during pregnancy. From literature and exploration, it was observed that self-management of a pregnant woman largely involved making key decisions concerning weight, nutrition, monitoring symptoms of pre-eclampsia and danger signs. To reflect that, this suite was packaged with four services namely; weight management, preeclampsia, nutrition, and self-diagnosis.

The **"Weight Management"** service was specifically implemented to keep track of a mother's weight during pregnancy and subsequently help in making important decisions concerning her general well-being. It was discovered during exploration that many women paid less attention and were less concerned about weight issues. As observed during the hospital visits, weight was measured using an analog weighing scale, and the results recorded in the ANC books/cards. However, health care providers did not offer an explanation on the implication of the weight results because they only measured weight in kilograms (mass) without factoring in height, which is a wrong parameter of assessing whether one is over or underweight. Therefore this service was aimed at computing and recording a mother's BMI which factors in both weight and height. When a pregnant woman clicks on the weight management tab, four clickable tabs are visible, *calculated BMI, calculate BMI, BMI report and about weight. Calculate BMI* tab was a service instantiated to allow a pregnant woman compute her BMI by providing her weight in kilograms and height in cm. The date is auto-generated reflecting the day the BMI is computed. When you click the *save* button, this information is sent to the database. Mothers are required to provide this information from time to time during their pregnancy in order to keep track of their weight fluctuations if any.

The *calculated BMI* shows a summary of all the BMI measurements taken during pregnancy, most importantly, it provides a mother with a status to show whether she is overweight, underweight, obese or normal weight. All expectant women whose BMI falls below 18.5 are considered underweight, 18.5-24.9 normal weight, 25.0-29.9 overweight and 30.0 and above

obese. This information is very important because it enables a pregnant woman make important decisions in regard to her weight during pregnancy.

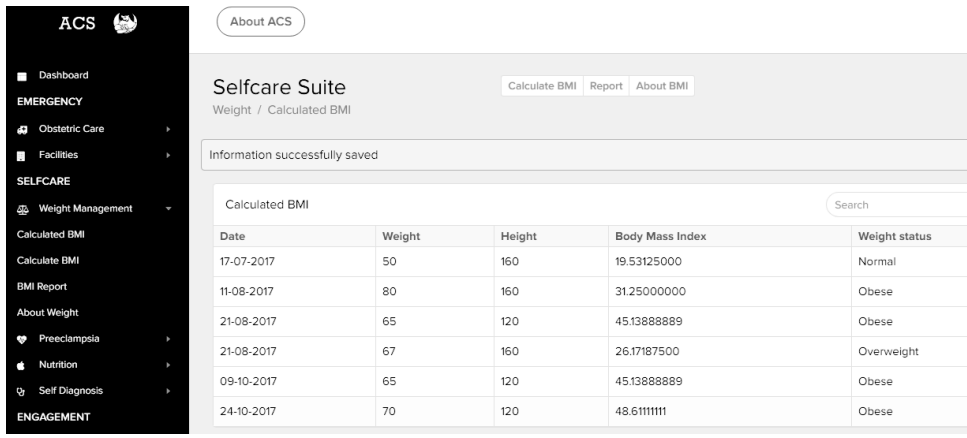

Figure 5-6: Summary of Calculated BMI

The *BMI report* service shows a graphical representation of the weight of the mother throughout her pregnancy which information is picked from the *calculated BMI* service. This visual representation is to quicken the decision making process for a mother, but also this information can also be used by the health care providers to offer advice where necessary.

Figure 5-7: Summary of BMI Reports

The *About Weight* service provides general information about weight which includes; information on permissible weight gain of a mother carrying one or multiple-pregnancies, information on the dangers that are associated with maternal overweight and underweight, among others. It was discovered during exploration that most pregnant women had no idea of

why they measure their weight why it was important to keep weight within an optimal range and the dangers associated with either maternal overweight or underweight. Yet, this information could be important in making various decisions surrounding general weight management like sticking to a balanced diet, living a healthy lifestyle which may entail a few supervised exercises and a decision to seek professional help about weight management.

The ***"Preeclampsia"*** service was intended to help pregnant women make critical decision to seek quick care should they experience conditions symptomatic to preeclampsia and also, capture, manipulate and store BP measurements of pregnant women overtime, which information can later be used by the mother to make relevant decisions.

On clicking the *"calculate BP"* tab, a pregnant woman enters her systolic and diastolic reading plus any remarks from the doctor. The date is auto generated reflecting the actual day the BP readings were captured. A save button posts the information into the database which is viewable on clicking the *calculated BP* tab.

The *"calculated BP"* service displays a summary of the mother's BP readings throughout her pregnancy and most importantly, she is in position to know the status of her BP whether low, high or normal (see fig.5-8). This information can be used by the mother to keep track of her BP and where possible make decisions to adjust her lifestyle or seek professional help from time to time should the BP readings vary from normal over a given period of time throughout her pregnancy.

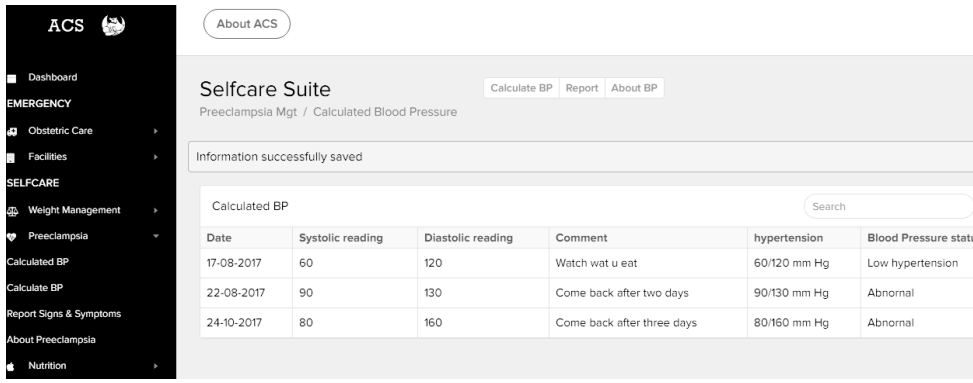

Figure 5-8: Preeclampsia "Calculated BP" service

The *"report signs and symptoms"* service was instantiated to allow mothers experiencing conditions symptomatic to preeclampsia make quick decisions to seek care. As earlier discussed in chapter one and two, the delay to seek medical care and reaching hospital late

resulted from mother's not knowing the severity of their conditions and as such died of conditions that would rather be prevented. Hence, a mother experiencing symptoms such as convulsions, visions issues, cramping of the lower abdomen, seizures, severe headache among others as demonstrated in this service, clicks the "report signs and symptoms" tab that displays a list of these preeclampsia symptoms. When a selection is done, a submit button at the bottom of the page is clicked and the message is automatically relayed to the midwife and the CHW the mother is attached to. This message is appended with the current physical location of the mother, date and time stamp. The midwife and CHW are able to respond to the mother by engaging her through the engagement suite *"private chat"* service and where possible prepare transportation services to the nearby health facility. This kind of collaboration is aimed at providing a quick response and reducing on the *delay time* between which a mother experiences a problem and when she gets professional help. Through the *facilities* service in the emergency suite, a pregnant woman views hospitals within her proximity to go to.

The *"share past experience"* service was instantiated for pregnant women to share their experience in relation to the past occurrences of preeclampsia if any. This information is posted on the pregnant woman's timeline, viewable by all pregnant women registered with the studio. The rationale behind the implementation of this service was to enable other pregnant women, who might experience the same be in position to make fast decisions on how best to handle and deal with the situation. This passive method of sharing information helps other pregnant women deal with the situation in a more apprehensive and informed way.

The *"about preeclampsia"* service provides general information about preeclampsia, likely causes, symptoms and the dangers associated with the condition. This information is meant to help enlighten a mother more about the condition and subsequently help her make informed decisions since many pregnant women were discovered during exploration to be lacking a lot of this information.

The **"Nutrition"** service was implemented to help pregnant women make decisions about what to eat, in what proportions, and what's not permissible for them to eat. As discussed in chapter three, many pregnant women had no idea of what they were supposed to eat, why, when, how and in what proportions, yet nourishment is fundamental for the growth of the foetus and the mother. This service once clicked, displays five clickable tabs in form of services that enables a pregnant woman to record her daily meal, store and retrieve information for purposes of decision making.

The *"record new meal"* service when clicked displays five major food groups that are vitally important to a pregnant woman. These include fruits, vegetables, diary, protein and grain, however, the most available and commonly consumed food types for each food group in Uganda were considered in this studio. A mother on a daily basis records what she has consumed by clicking on each food group as demonstrated in figure 5-9 below. When a *save meal* button is clicked, the information is compared against a standard meal serving of a pregnant woman, saved in the database and retrievable when a user clicks the *"recorded meal"* service.

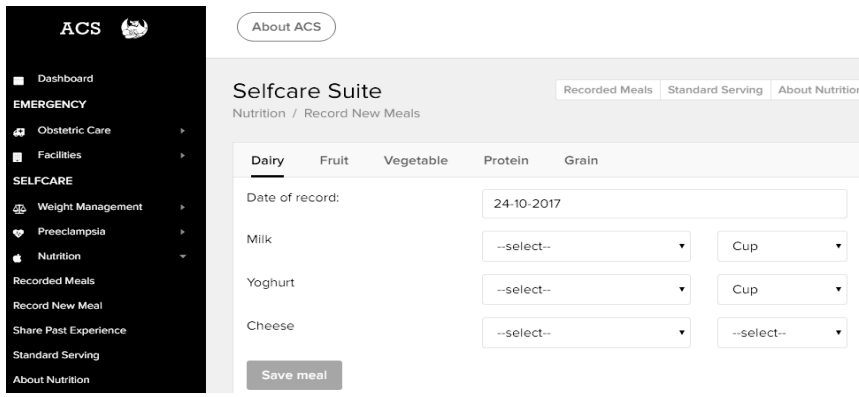

Figure 5-9: Nutrition "Record New Meal" service

The *"recorded meals"* service when clicked displays summary information of what was consumed the day before and in what proportions. This information computed and stored in the database enables a mother know what they are deficient in if any and in what quantity. This information is displayed in the *consumption status* highlighting whether the user is consuming more, less or the required proportions of a particular food group. This is key in helping a mother enhance her decisions concerning her diet and nutrition.

The *"share past experience"* service enables a mother to record, document and share information in regard to what she consumed, possible effects and any other important information regarding nutrition. The information is posted on the pregnant woman's timeline accessible by all registered users, who can also comment, give advice or share their own experience. This interaction is important because a lot is shared by other mothers acting as basis for other pregnant women to make decisions that would have rather been hard to make, and subsequently health care providers can use this avenue to engage with the pregnant women on issues of nourishment.

The *"standard serving"* service once clicked displays all the food groups together with portions that a pregnant woman is supposed to take on a daily basis. Each tab has a collapsible drop-down menu containing food types and quantities to be consumed. This information is meant to help a pregnant woman aware of the daily food permissible in her diet and consequently make relevant decisions to that effect.

The process flow in the self-care suite begins when a pregnant woman records her weight, preeclampsia, nutrition and views her reports on the same. Based on what the pregnant women inputs, the midwife and CHW views and monitors the status of all pregnant women under their watch. The chief midwife views and monitors all the pregnant women's reports attached to the health centre they manage. However, in sub-suites (preeclampsia and nutrition) where the pregnant woman shares her experience, the shared information can be viewed by either ONLY individuals of her health centre or all individuals of other health centres. This depends on what the pregnant woman decides before sharing the experience, that is, access limited to health centre or access not limited. All these checks and balances where put in place to ensure privacy and security of the information that is being exchanged on the studio.

Engagement Suite

The engagement suite is a virtual space in the ACS where all stakeholders or registered users come to share, exchange and discuss ideas pertaining to antenatal care. Since antenatal care involves different stakeholders all aimed at achieving a common goal, the instantiation of this suite served this purpose. In order to achieve collaborative communication, the suite was packaged with three major services, the private chat, group chat and the user's timeline. Unlike the other suites, all services under this suite can be used by any user role. These include, initiating a private chat, creating a group chat, adding members to a group chat, posting content onto the timeline, replying to posts of other individuals. Information exchange under this suite cuts across all suites.

When the *"private chat"* tab is clicked, a list of all available users is displayed. A pregnant woman can select or use the *search* function to get her preferred user to engage with as illustrated in fig.5-10 below. Once a user has been selected, an HTML form is loaded at the extreme right of the window indicating the user and the last time/date they appeared online. A pregnant woman has a choice to select the person to engage with based on preference or online availability. The *"type a message"* section allows a user to initiate a message and if there is a document(s) to share, clicking the *"choose file"* command button at the bottom of the page

enables a user to browse through the storage to append a file. When all is done, a *"send"* button at the bottom of the page is clicked that posts the information on the recipient's interface, who, if online can respond immediately or when they next avail themselves online.

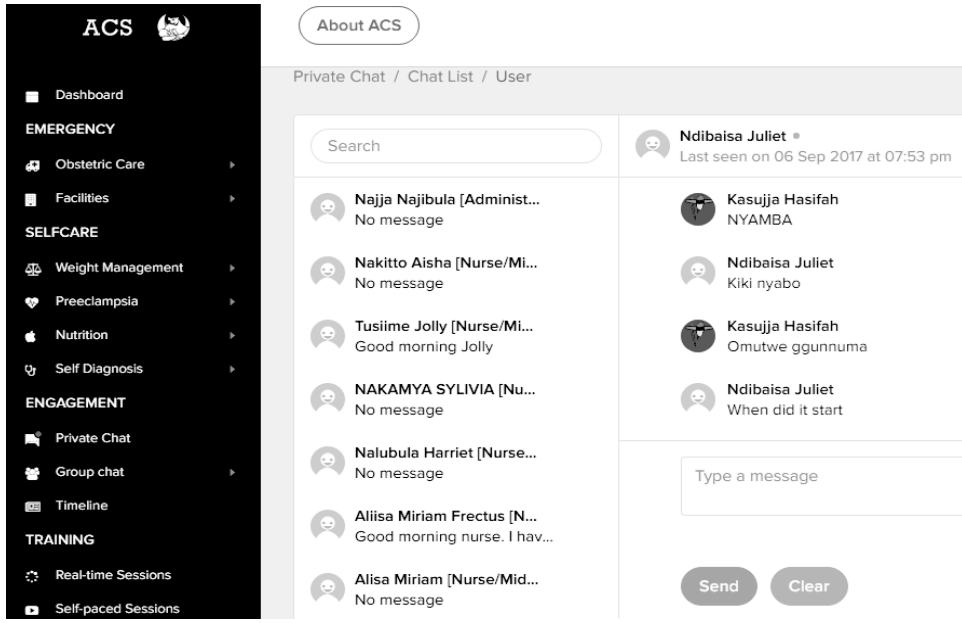

Figure 5-10: Engagement Suite "Private Chat" service

When the *"group chat"* service is clicked, which is a collapsible tab, two more tabs are viewable, the *chats* and *create group* tabs. For a group chat to be initiated, the user first creates a group by clicking on the create group tab. This loads an HTML form which allows the user to create a group name and a short description for the purpose of the group, before a save button is clicked. However, if the group to which a mother wants to interact with was already created, then she double clicks it and straight away create a message. When this is done, this information is posted in the database and the created group will by default register the user that created it as a member and administrator of the group.

After the group has been created, the user clicks the *"chat"* tab under the *"group chat"* drop down menu and a new web page is loaded. The page is sub-divided in four sections. The left hand side after the main menu lists all the groups created, the next section displays the selected group that the mother wishes to engage or interact with. However, before the chatting begins, the creator of the group has to first add members to the created group which is done by clicking on the *"add member"* tab at the extreme right of the page. After adding members, then the user

can initiate a message by clicking inside the *"type a message"* text box. When the "*send message"* button at the bottom of the page is clicked, the message is displayed in the mid-section of the web page plus all other correspondences from the active members of the group. All messages posted are appended with the user's profile name and picture for purposes of identity.

The ACS *"timeline"* service is a converging point for all ACS users. This ACS was designed to facilitate creation and content sharing in form of information, ideas and other forms of expression among vast users of the studio. Once a user clicks the *"timeline"* service, a new HTML page is loaded with a text box provision for sharing information with other users of the ACS. Once a post is submitted, it's visible to other users with a *"comment"* and *"reply"* tab to allow users to react on it. A user who wishes to comment on a post clicks the *"comment"* tab that loads a new page together with the initial post. After commenting on a post, the user clicks the *post* button which renders both the initial post and the new comment viewable to other users. The timeline shows all the messages in form of a thread and a "*comment count*" showing the number of users who commented on a particular post. The ACS timeline offers a collaborative and interactive avenue that allows user-generated content in form of text posts or comments to be exchanged through online interaction, and as such is a place where different actors of the studio share experience and insights regarding antenatal care.

Training Suite

The training suite was instantiated to offer an opportunity to a great audience of expectant mothers who can't make it for antenatal care services. The suite offers two main services; real-time sessions and self-paced sessions. The community health worker, midwife or chief midwife are the only users who can schedule a training session.

The *"real-time session"* service was implemented to allow either the CHW or midwife interact with the pregnant women instantaneously. This was after it was discovered that some women did not attend antenatal care because of the distance to the health facility or the lack of transport. It was against this background that this service was instantiated. When a training session is created, the time and date of the training is indicated and all interested users subscribe to the session. Real-time sessions are conducted through video conferencing to allow visual collaboration among users of the studio.

The *"Self-paced session"* service was implemented to allow users who can't afford or make it for real-time sessions have an opportunity to share what was discussed. When the user clicks

the self-paced tab, a new html page is loaded containing a list all videos, the date they were uploaded, the instructor of the video and who uploaded it. Emphasis on "*who uploaded"* was very vital because only a midwife or a CHW can upload any content in the training suite. This was done to ensure that the integrity and authenticity of the data is kept intact and also for accountability purposes.

In the training suite, the ACS uses the videoJS API to accommodate live streaming of training sessions. This API is in charge of managing content and allowing the ACS to control video streaming. The videoJS was supported by videoSTAR data model that was in charge of the management of media in the ACS, sharing video information among different users of the ACS. The core function of the videoSTAR data model is the *media stream* which captures the features of continuous media data.

Messaging Suite

The messaging suite was instantiated with the "AC reminder" and "alert" services because it was discovered during exploration that most women forgot to go for antenatal care and also lacked basic information on issues related to pregnancy. Therefore, sending messages and constant reminders was assumed to be a driving factor for women to visit health facilities for antenatal care. Getting information about certain aspects of antenatal care is paramount for decision making during pregnancy.

The *"alert"* services was predominantly implemented to help pregnant women from time to time get information regarding pregnancy, childbirth, child care, hygiene, diet among others. Availing information is one avenue that ensures women get adequate antenatal care information for decision making and as Keen and Sol (2008) postulate, the notion of decision enhancement hinges on keeping the decision maker in the loop. The administrator of the ACS can compose and send out messages on mobile phones of all pregnant women registered with the studio on a weekly basis. Important to note is that even women with non-smart phones were registered with the ACS by the CHW and/or midwife, implying that they could receive messages regardless of the type of phone they had. The content of the messages were designed both in English and Luganda for better comprehension. *Luganda* is the most commonly spoken language in the region. Therefore, for messages to make meaning to the recipient, localizing the content was found prudent. When a user clicks the *"alert"* service, an HTML page containing a list of messages so far received is loaded.

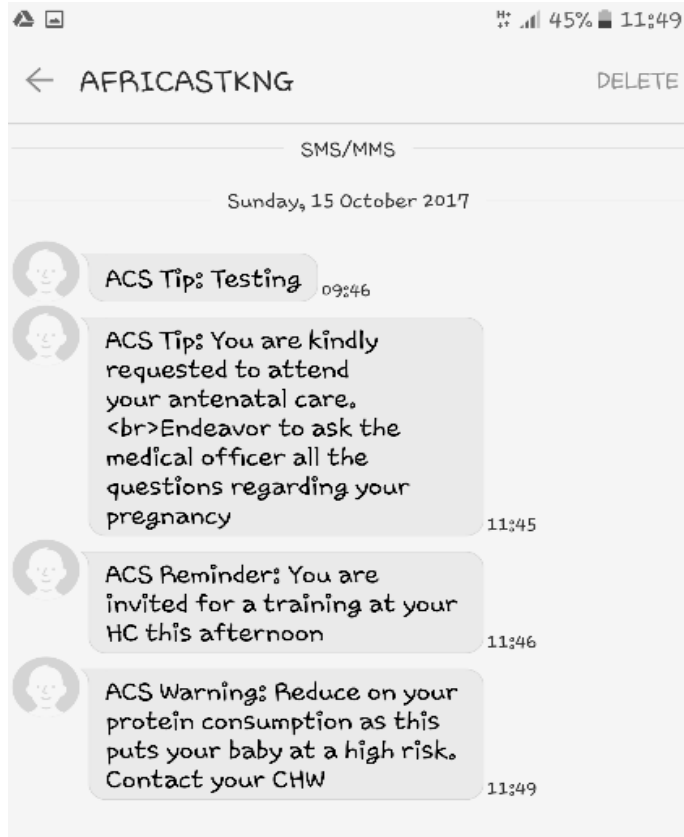

Figure 5-11: Alert "Text Message" Services

The *"AC reminder"* service was incorporated in the studio to help mothers activate their ANC appointment dates. When a user clicks on the AC reminder tab, an HTML page loads which displays when to show the reminder usually expressed in minutes before the event start time. The service not only allows the studio to retrieve the users' existing calendar and reminder data, but also lets you create, edit and delete events and reminders (collectively known as calendar items). Additionally, this service allows for adding alarms and specifying recurring events. The reminder triggers an alarm at a specified time before the actual event which is displayed on the user's phone as a pop-up. Subsequently, all trainings scheduled to take place at a future date are automatically reflected as a calendar item in form of an event.

5.3 Data Integrity and Authenticity

The ACS is a facilitative, interactive and collaborative platform having various stakeholders sharing and exchanging information. However, considering that the studio deals with health

information, ensuring data integrity and authenticity was of utmost priority. Data integrity is the trustworthiness of information over its lifecycle (Boritz, 2011) and should be uniform, complete, unchanged and secure. All users of the system were required to register login details, which were later used whenever they accessed the studio. Usernames and passwords were encrypted, access controls were ensured which included assigning read/write privileges, input validation to prevent incorrect data entry and data validation to certify uncorrupted transmission. To further ensure integrity of data in the database, both entity and referential integrity rules were employed and authenticated through use of error checking and validation routines. The entity integrity and referential integrity rules are MySQL constraints implemented in form of primary keys and foreign keys at the time of creating database objects. This was all intended to ascertain that data was recorded as intended and upon retrieval, ensure that data was the same as it was originally recorded. For the information that was shared on the user's timelines and in the engagement suite, the studio administrators appointed a few midwives and subject matter experts to verify the authenticity of the information.

CHAPTER 6 – EVALUATION OF THE ANTENATAL CARE STUDIO

This chapter provides a detailed description of the evaluation process that was undertaken to test the functionality, quality, efficacy and practical utility of the ACS. A systematic and rigorous approach was employed to ascertain that the ACS is useful and easy to use. Section 6.1 describes the evaluation approach, 6.2 evaluation criteria, 6.3 the evaluation procedure, setting and results, 6.4 the discussion of results.

6.1 Evaluation Approach

Papaconstantinou and Polt (1997) define evaluation as "*a process that seeks to determine as systematically and objectively as possible the relevance, efficiency and effectiveness of an activity in terms of its objectives, including the analysis and the implementation and administrative management of such activity*". Helfert and Donnellan (2012) postulate that evaluating a design science artefact calls for particular focus on both practical utility and academic rigor. Similarly, Venable et al (2014) posit that artefact evaluation is an avenue for providing feedback for further development. A naturalistic evaluation was adopted in a practitioner-oriented environment to test the practical utility of the ACS. This involved testing the solution with real people in a real setting. Several researchers (Venable et al. 2014; Sun & Kantor, 2006) contend that the naturalistic evaluation improves the quality of the knowledge outcomes concerning the artefacts effectiveness in real use unlike an artificial setting. Simon (1996) posit that a design product is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve. The ACS was intended to address decision making challenges among expectant women in Uganda as well as contribute to the knowledge base in the scientific community.

Theory building, instantiation and evaluation were tightly interwoven processes employed in this study to ascertain and validate the design process and the design product. Hevner et al (2004) stress that artefact evaluation should rigorously demonstrate the utility, quality and efficacy of a design artefact via well-grounded evaluation methods. Furthermore, Nunamaker et al. (1991) advocate that all design science artefacts must be testable, realizable and generalizable. Several researchers (Pries-Heje et al. 2008; Peffers et al. 2008; Vaishnavi and Kuechler, 2007; Hevner et al. 2004; Nunamaker et al. 1991) propose various artefact evaluation and validation techniques which include demonstration, simulation, experimentation (lab or case study), using metrics, benchmarking, logic reasoning, mathematical proofs, field studies, dynamic analysis, expert evaluation, functional testing, action research among others. Peffers

et al. (2008) stressed that artefacts should be evaluated based on the requirements of the context in which the artefact is implemented, according to Hevner et al (2004) for example in terms such as "functionality, completeness, consistency, accuracy, performance, reliability, usability among others." This research employed a mixed method evaluation approach which included; i) case study demonstration involving testing the ACS with expectant mothers, and ii) experimental testing with midwives and CHW's. These techniques were employed as proof of concept to ascertain that the functional and user requirements of the ACS do fit the purpose.

The evaluation of the ACS involved 12 industry and domain experts (7 midwives and 5 CHW's), 100 decision makers (expectant mothers) and 14 peer mothers. Of the 100 expectant mothers who registered and consented to participate, 62 had smart phones. The 62 participants fully interacted with the studio utilizing all facets of the studio. The criteria used for the evaluators to be part of the exercise included i) evaluator consent, ii) decision makers had to be expectant mothers with smart phones, iii) peer mothers had to be with babies not more than 2 years, iv) familiarity with technology, v) all expectant mothers who had earlier participated in the exploration study were now considered peer mothers, vi) community health workers needed to have experience in community engagement for at least two years, and vii) midwives needed to have attained a minimum of a bachelor's degree with a two year experience in the field of antenatal care or information systems development.

Purposive sampling was used to select the evaluators who met the criteria for the evaluation exercise. This sampling technique was used because it offered a better judgement to select from the population participants who would give the desired or accurate information (Annum, 2016). Participants were purposely handpicked from the population based on the researcher's knowledge and judgement. Domain experts (midwives and community health workers), expectant and peer mothers were chosen from the different health facilities around central and eastern Uganda. Health facilities used in the central region included Rubaga hospital and Kisenyi Health Centre IV while in eastern region, Walukuba health centre IV was used.

6.2 Evaluation Criteria

This study employed the technology acceptance model to evaluate perceived usefulness and ease of use of the ACS. The Technology Acceptance Model hypothesizes how users come to accept and use a technology, which decision is usually influenced by a number of factors (Davis, 1989). These factors (perceived usefulness and perceived ease of use) influence how and when users will adopt a technology. Davis (1989) defines perceived usefulness as "*the*

degree to which a person believes that a particular system would enhance his or her job performance" while perceived ease of use *"is the degree to which a person believes using a particular system would be free from effort"*. Keen and Sol (2008) also stressed the importance of usefulness, usability and usage in studio evaluation. They define *usage* as the actual application of the studio in antenatal care practices. Several researchers (Swanson, 1987; Bandura, 1982; Robey, 1979) mentioned a high correlation that exists between perceived usefulness and system usage.

In relation to this research, *perceived usefulness* is the degree to which expectant mothers believe that the ACS is beneficial and important in enhancing their antenatal care decisions. Throughout the evaluation process, emphasis was put on perceived usefulness, usage and usability of the ACS as a way to ascertain that the product does address the decision making challenges faced by expectant mothers in Uganda.

Table 6-1: Evaluation Criteria

Method of Evaluation	Aspects Evaluated	Evaluators	Number
• Focus Groups • Interviews • Workshops	• Usefulness • Usability • Usage	Midwives and Community Health Workers	12
		Expectant mothers	62
		Peer mothers	14

The evaluators played different roles in the evaluation exercise of the ACS artefact as summarized in the table 6-2 below.

Table 6-2: Roles of the evaluators

Evaluator	Role
Midwives and CHW	• Ensuring practical utility • CHW registered non-smart phone users with the studio • Participate in regression testing • Providing feedback on ACS
Expectant mothers	• Evaluating user requirements • Ensuring practical utility • Undertake tasks to ensure decision making capability • Provide feedback on ACS • Participate in regression testing
Peers	• Ensuring practical utility

	• Providing feedback on ACS

During the evaluation exercise of the ACS, we assessed the extent to which users believed the artefact would help them perform their decision making tasks successfully (perceived usefulness), the degree to which using the ACS would be free of effort (perceived ease of use) and the actual application of the studio in their decision making practices (usage).

6.3 Evaluation Procedure

Design science artefacts must be rigorously evaluated via well executed evaluation methods (Venable et al, 2014). Therefore, this study's primary method of evaluation was collaborative workshops which allowed active engagement of the researcher and the respondents. These sessions were aimed at equipping the users with the skills of using the studio but also use them as feedback sessions. All verbal responses were recorded using an audio recorder and data was later transcribed. At the end of these workshops, participants were requested to experiment with the studio for some time and later, questionnaires with both qualitative and quantitative responses were given to them to assess the studio. These sessions helped in getting a much broader picture of the user's perception of the ACS and at the same time complemented information from questionnaires. Questionnaires comprised of two sections; the open-ended and closed-ended questions. The rationale behind this questionnaire format was to provide a deeper understanding of the general outlook and insight users had of the ACS. Questionnaire responses were rated using the Likert five-point scale (Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4 and Strongly Agree = 5) where respondents specified their level of agreement or disagreement for a series of statements and as rightly stated by (Burns and Burns, 2008) these ranges capture the intensity of the respondent's feelings for a given time. The Likert scale enabled us to tap into the cognitive and affective components of the user's attitude towards the ACS. The quantitative results were presented according to the mean, mode, and standard deviation while the qualitative responses were analysed using conventional content analysis. In using conventional content analysis, the data that was collected was read repeatedly to try and identify any patterns. Word by word, data was read, exact words or statements from different questionnaires were highlighted from the text with the purpose of encoding it. The kind of data that was being analysed was written text from the evaluation questionnaires, oral and audio data from the evaluation sessions. The rationale for using conventional content analysis is its ability to maximize diversity of emotional reactions (Shannon & Hsieh, 2005).

Evaluation setting

The evaluation approach focused on midwives, community health workers, expectant mothers and peers with the intent of evaluating the studio's usability, usefulness and usage. Initially, workshops were first organized with the participants and then a few members were randomly selected to engage in focus group discussions which lasted no more than an hour intended to provide a deeper understanding of the user's perception of the ACS.

Evaluation with the Expectant Mothers

A five day orientation workshop which commenced on the 22nd – 26th of May 2017 was conducted with expectant mothers with the purpose of assessing the practical utility of the studio and establish that all requirements were fully operational. These are the sole beneficiaries of this studio hence, the sessions entailed demonstration of all the suites and services therein. A recap of the research problem was done together with the objectives, findings, proposed solution and the purpose of the evaluation session. Expectant mothers registered with the studio and practical demonstrations were done to ensure that mothers had fully grasped their way around the studio. During these sessions, mothers were assigned midwives and community health workers to work with throughout the evaluation period. At the end of the workshop, expectant mothers were asked to apply the studio to their routine antenatal care practices by using the different suites and services through practical experimentation for a period of four months. The period given was enough to test both user experience, usefulness and usage of the ACS in the decision making practices of expectant mothers.

Table 6-3, 6-4 and 6-5 represent evaluation results from expectant mothers assessing usefulness, usability and usage. The evaluation results presented were as a result of the mothers practically experimenting with the ACS. The quantitative evaluation results provided the researcher with the user's perception towards the usefulness, usability and usage of the ACS. The mean, mode and standard deviation were used to; i) give a snapshot of how participants are responding in general and, ii) to ascertain how far or close their responses were.

Table 6-3: Evaluation results assessing usefulness of the ACS done by Expectant Mothers

	Mean	Mode	Std. Deviation
ACS improved my knowledge on antenatal care (U1)	3.97	5	1.201
ACS improved my knowledge on danger signs, nutrition, and preeclampsia (U2)	4.32	5	.864
ACS improved and strengthened my relationship with midwives (U3)	4.32	5	.805
ACS improved and strengthened my relationship with community health workers (U4)	4.08	4[a]	1.106
ACS made it easier for me to remember to go for antenatal care through messages sent (U5)	4.35	5	.870
I was able to keep track of my diet in order to improve on my nutrition (U6)	4.05	5	1.062
ACS improved the emergency response time because CHW responded immediately on receiving the emergency alert (U7)	3.98	5	1.261
ACS quickened my decisions to seek care in the event of a warning sign or signs of preeclampsia surfaced (U8)	3.79	5	1.307
I have been able to get solutions to problems quickly through engaging medical personnel, CHW and peers (U9)	4.37	5	.683
Using the ACS helped me better understand likely problems to experience during pregnancy therefore act upon them (U10)	4.27	5	.908
There is added value in using the studio (U11)	4.23	5	.931
It became easy to refer to old discussions as all logs were automatically saved (U12)	5.00	5	.00
I liked using the systems (subjective satisfaction) (13)	4.37	5	.773
Average Mean	4.17	4.91	0.98

Results in table. 6-3 summarises mothers' responses in as far as usefulness of the studio was concerned. Mothers strongly agreed that the ACS strengthened their relationship with the community health workers and midwives, enhanced their antenatal care decisions and made it easy to remember to go for ANC services. They further reported that there was easy access to information, emergency alerts were considerably responded to within a short time and generally they enjoyed using the studio. An average mean of 4.17 strongly suggests that the expectant mothers perceived the studio useful and therefore enhanced their decision making practices. A standard deviation of 0.98 reflects a less significant difference of expectant mothers' viewpoints.

Table 6-4: Evaluation results assessing usability of the ACS done by Expectant Mothers

	Mean	Mode	Std. Deviation
I find the ACS easy to use (E1)	4.02	5	1.204
Learning how to use ACS was easy for me (E2)	4.11	5	1.103
It is easy to become skilful at using ACS (E3)	4.35	5	.851
The information was easily accessible (E4)	4.26	5	.957
After learning the system, navigating was very easy (E5)	4.37	5	.854
The language was simple and easy to understand (E6)	4.37	5	.773
I did not always seek for help when using the studio (E7)	4.47	5	.783
I used the help function rarely (E8)	4.21	5	.960
I have experience in using mobile web technologies (E9)	4.23	5	.948
Average Mean	4.26	5	0.93

Table. 6-4 summarizes results of expectant mothers' opinions towards the usability of the studio. With an average mean of 4.26, this means that expectant mothers strongly agreed that the studio was easy to use, understandable and intuitive. They further affirmed that it was easy to become skilful at using the ACS and that they sought little help when using the studio. A standard deviation of 0.93 a figure not far away from the mean, further confirms that the opinions of these 62 mothers were not different.

Table 6-5: Evaluation results assessing usage of the ACS done by Expectant Mothers

	Mean	Mode	Std. Deviation
I have diligently been using the ACS throughout my pregnancy	4.58	5	.515
I will continue to use the studio during my antenatal care practices	4.42	5	.669
Usage of the ACS did not reflect the right context of antenatal care practices	1.58	1	.900
The guidelines were easy to follow while using the ACS	4.67	5	.492
I would recommend other mothers to use this studio	4.92	5	.289
I enjoyed using the studio (subjective satisfaction)	4.67	5	.492
Average Mean	4.65	5	0.48

From the results displayed in table 6-5 (usage), mothers strongly agreed to having been using the studio throughout their antenatal care period, will continue using the studio and recommend others to use it. They further noted that the guidelines were constantly used and their general user experience was remarkable. However, a negatively formulated statement *"ACS did not reflect the right context of antenatal care practices"* was strongly disagreed upon reflecting that the mothers responses were not biased but echoed what they actually did with the studio.

With an average mean of 4.65 and a standard deviation of 0.48, it can generally be concluded that the studio was used.

Qualitative Evaluation Responses

Throughout the four months of evaluation, three focus group meetings were organized with expectant mothers to assess usefulness, usability and usage.

First Focus Group

Approximately after seven weeks from the first evaluation workshop, a meeting was organized with the purpose of evaluating usability, strengths, any issues so far encountered while using the studio and also remind the participants of the objective of the exercise. On the 20th-July-2017, the researcher met 57 expectant mothers. A usability testing was done and unlike the first session, participants were left to interact with the studio without being given prior assistance. Purpose was to find out any usability problems or issues and monitor participant's interaction with the studio. This user experience was being observed by the researcher, listening and taking notes. During the usability testing, it was observed that some participants were quickly navigating the ACS while others were still having issues. Those that had problems felt comfortable asking fellow mothers for assistance because they were familiar to them than the researcher. In one of the sessions, some mothers expressed their comfort working with community health workers. It was from this point on that CHW's, who were known to most of the mothers facilitated the workshops. The researcher took on an observatory role while closely watching the mother's interaction with the ACS and CHW.

After this session, we then randomly selected 7 mothers from the 57 participants who we further engaged in a focus group discussion. This focus group lasted 75 minutes and was intended to get an in-depth insight into the studio's usability and challenges experienced (if any). The usability questions that guided the discussion included: 1) Do you find the ACS easy to use? 2) Was is it easy to find what you wanted? 3) Was the language understandable? 4) What challenges did you find while using the ACS?

Discussion of mother's responses begins with a summarized list that was ranked according to the number of times it was mentioned during the focus group meeting. This is followed by an explicit explanation of expectant mother's narrative about their opinion and experience. Excerpts from FGD and anecdotal evidence was integrated into the narrative to give the reader a better understanding of the mother's experience. Some narratives from different participants were in local language, however, all content was translated into English. Below is a summary

of responses that were commonly expressed by the mothers during the focus group discussion which were later followed by elaborative anecdotal statements.

Usability Challenges
- Internet was a big problem
- Midwives took long to respond to requests
- Registration process was long
- Recording meals was challenging
Usability Strengths
- Registration process was direct
- Engaging in a chat was very easy
- Registering an emergency was simple
- Recording BP was straight forward
- Information on nutrition was very easy to find and understand
- Using the weight service was easy

Overall perception on the usability of the ACS was positive

Women were asked what they understood from the term mobile web technologies, whether they had used them prior the ACS and how often they used them. Except for one, the rest acknowledged knowing these technologies defining them as "*websites on the smart mobile phone*" while others defined it as "*technologies like whatsapp or facebook*" when asked whether they used facebook, whatsapp or skype on their phones. Apart from skype, mothers nodded in acknowledgement and admitted using facebook, whatsapp technologies on a daily basis. When asked about ACS and the ease they found using it, on a scale of 1-10, 1 being "very difficult" and 10 reflecting "very easy", majority (5 out of 7) of the mothers described the ACS as easy to use with the majority rating it at 6 and above. Many of them described the ACS as *"...not very different from facebook"* while one mother in particular referred it to "*....second midwife"*. One mother offered a statement that was representative of the opinions of many of the focus group participants; this statement sums up the ease they found while using the ACS.

> *'When I entered the website in my browser, the page loaded very fast, the login and registration tabs were out-rightly visible. I had registered in the earlier sessions so I just logged in. I wanted to ask the midwife whether it was fine for me to use "emmumbwa" (a local block of clay that is mixed with local herbs). I located the private chat very quickly and it was very simple to initiate a conversation with the midwives. My conversations with the midwives were in "Lusoga" (a native language) which made interaction even much simpler. Also, I am a hypertensive person, I recorded my blood pressure regularly, so I didn't have to walk with my antenatal book. In the event I got a problem, any doctor would review the history of my blood pressure on my phone.'*

Other mothers alike noted that using the ACS in their routine antenatal care practices was not hard. This was especially true for mothers that were constantly using their smart phones for other services like facebook, whatsapp and twitter. As one expectant mother explained, *"It was easy for me to get information about the different food groups, recording meals though sometimes I forgot"*. One mother particularly described the ACS as a lifesaving tool for many mothers in Uganda, and in her expressions she narrated *"I had an excruciating headache for two days and on the third day, I decided to seek medical attention, the ease with which I located the emergency suite, tapped and sent the request was remarkable"*. A CHW responded and advised me to seek medical attention in a different hospital which was further from the one recommended by the studio but offered all maternity services.

When asked of the challenges they had so far experienced, 1 out of 7 expectant mothers described a sense of *"anxiety"* about using the ACS and that it was challenging because they had *"never used their phone for anything apart from calls and messages"*. A number of mothers said it was very challenging to access internet because *"it was not affordable"* while others described their locations as *"…being remote"* so internet access was not good. Many mothers expressed their will to use the antenatal care studio but they felt that *"midwives took long to respond to their requests"…*or *"the registration process was long"* or *"recording meals was challenging"*. These feelings of frustration are summed up in the words of one mother who narrated:

> *'I have tried to use the emergency suite twice however I always get responses from the midwives 3-5 hours from the time I submit a request. But the CHW respond promptly. Also, the registration process is long, the good thing it is a one-off. I really like recording my meals such that I know at the end of the week what I am deficient in, but having to record every meal I take is tasking and sometimes I even forget.'*

Based on the challenges that were documented, it was concluded that some users hadn't fully gotten acquainted with the studio to understand its navigability, functionality and purpose. Another workshop was organized on the 24th–July-2017 which involved practical demonstrations of the studio and its benefits. At the end of the workshop, a simple Q and A session was done to make certain that the users had benefitted from the session.

Second Focus Group

This meeting with expectant mothers was organized on the 4th –Aug-2017 to establish the progress of studio usage and find out whether the challenges earlier mentioned were partially or wholly addressed. This meeting which was partially facilitated by the community health workers was conducted to ascertain the usefulness of the studio. Of the 83 mothers that were invited, 62 turned up. In this second meeting, many seemed not to be experiencing major challenges with navigating the studio. Participants were under watch as they navigated the studio and most mothers interacted freely with the CHW's better than the first two meetings. The aspect of using the CHW during these assessment meetings was to build trust, reduce tension, anxiety and nervousness among expectant mothers. Most mothers at this moment appreciated the studio and evaluating usefulness took center stage. Of the 62 mothers that turned up for this session, 10 participants were randomly selected to participate in the focus group discussion.

Mothers were asked question pertaining to usefulness of the ACS. The questions that guided this discussion included; 1) Did the ACS improve your knowledge of antenatal care? 2) Did the ACS improve your relationship with the midwives and CHW's? 3) Did the ACS improve your frequency of visiting the health center? 4) How did the ACS improve on your decision making practices? The summary below captures the most common opinions that were expressed by the mothers who participated in the focus group discussions.

- Information on the studio was helpful
- Weekly antenatal care messages were very appropriate
- Visiting health centres became routine rather than for emergencies
- The studio supported real-time exchange of information in the engagement suite
- Interacting with other users of ACS improved decision making
- The gap between midwives and CHW was considerably reduced
- Getting feedback, comments or views on the timeline was good
- Incorporating the CHW/midwife on mother's dashboard was useful.

Generally, the overall perception on usefulness of the ACS was positive

Mothers were asked to describe how useful they perceived the studio to be and to explain how they believed the studio influenced their decision making practices. Participants described how they used multiple services in the ACS to make fast and informed decisions. These views and opinions voiced by expectant mothers in the focus groups, are further explained below.

Mothers were quick to acknowledge the importance and value that the ACS had brought to them. For example, a number of mothers acknowledged having gotten a lot of information through interaction with the various users of the studio, they iterated that *"they would take long to get this information"* an evidence overall, that *"the studio empowered women to search for information and make informed decisions"*. Majority of the mothers who participated in the focus groups described the ACS as *"an avenue for building and strengthening relationships with care providers"*. Many of them narrated having increased the frequency of visiting hospital after realizing that no condition can be taken for granted during pregnancy. All the participants appreciated the weekly messages that they received that had different information concerning antenatal care and urged that messages *"be sent on a daily basis"*. These sentiments are captured in the comments of one of the participant who narrates:

'I personally have benefited a lot from using this technology. I can directly tell the midwife and the CHW what is bothering me and I get immediate feedback. Previously, I had little knowledge of danger signs and their consequences. But with this platform, I have even a direct access to report them and get instant help. Every time I post information or a question on my timeline, I get views, comments from other users. I am definitely more than 100% that this platform is of value to me and would recommend others to use it.'

Some of the focus group participants acknowledged the timely response that care providers had showed them. Others followed up on this point, indicating the value of "*getting things done quickly"* which was experienced with the studio. Many mothers attested to getting help from midwives and CHW's within a short time as one mother narrated.

> *'After long hours of vomiting, I decided to try out the studio and see whether it really worked. I was happy when the CHW responded after a few minutes and instructed me not to eat sweet, oily things however, he advised if vomiting persists, then I should to go to the hospital. A few hours later, the midwife also requested me to go to the nearest hospital.'*

The aspect of decision making among expectant mothers was an area many appreciated about the studio. Many participants from the focus group acknowledged to the fact that decision making had improved with this technology. As one mother, echoing a sentiment expressed by many mothers, stated: *"My decision to seek care in the past was highly dependent on my spouse who sometimes had little or no knowledge about what I was experiencing, with this studio, the decision to seek care is dependent on the advice that I get from the midwives and the community health workers".* Another mother emphasized further, the role the studio had to play when she had to make a decision about a health facility to visit, she stated:

> *'It was late in the night when I felt a sharp pain in the lower abdomen. It was very strange and the pain had a lapse of 2-3 minutes. I was 36 weeks and I knew it wasn't labour because I had at least 4 more weeks to due date, but as the pain intensified, I realised I needed to get to hospital because it was excruciating, deciding on which health facility to go to at that moment was mind-boggling until I logged into the studio, and using the "facilities service", the nearest hospital from my physical location was provided which eased my decision to seek care and the facility to go to.'*

The studio's ability to interactively allow users to communicate was emphasized by the participants as useful and relevant if antenatal care problems are to be solved. All participants agreed that the studio was *"participative"*, *"collaborative"* and *"educative"*. To emphasize these three aspects, participants stressed that the training suite was one of the avenues where all these were woven. The training suite, as was explained by one of the participants

"encouraged members to engage, participate as well as share information on pertinent issues of antenatal care." The studio was perceived by many participants as a tool that could enhance women's antenatal care decision making practices. This was drawn from the fact that mothers with emergencies could send emergency alerts which were automatically relayed to the midwife and CHW. Participants stressed that these alerts were in the studio, and the fact that alerts were tagged with the geo-location of the mother, one participant stated that *"this could solve so many delay problems that have contributed to the demise of many mothers in Uganda."*

For accountability purposes, participants felt that tagging the CHW and midwife in charge on the mother's dashboard was very useful. All the participants supported this and one participant shared his views, similar to what others had, and stated *"….not showing the CHW and midwife a mother is attached to would leave care at the discretion of the care providers hence, accountability becomes an issue"*.

Interwoven in the participants discourse, another interviewee appreciated the chatting service which was recommended as the *"next-best form of communication"* however, in his views which were consistent with the rest of the participants, he iterated and emphasized that:

> *'To benefit from the chat services, a group should have a maximum quota of at least 8 members. This is premised on the fact that having unlimited number of people in a group chat may cause people to bring in diversionary ideas and may be hard to engage in a fruitful discussion or session.'*

For continuity and effective utilization of the studio, all participants except one suggested for an offline version of the studio. They for example noted that the nutrition suite requires a mother to record her meals regularly yet internet connectivity seems a big challenge. This may cause inconsistencies in the data captured. These concerns were summarized by one of the participants whose views are similarly expressed by many others, he stated: *"….however, it is paramount to have an offline version of the ACS that permits a mother to for example record meals, then synch data when she next avails online. With this, missing out on important information which might affect the kind of decision that a mother makes is addressed."* By and

large, many appreciated the nutrition service because it made them cognizant of the mother's dietary needs.

Third Focus Group

This meeting was scheduled on the 21st-Sept-2017, a month after the last one was convened. The purpose of giving the users a month of studio interaction was to let them familiarize and interact more with the studio. With less complaints about usability, this made us confident that the users had fully gotten accustomed to the ACS. A focus group of 12 expectant mothers was organized to assess actual *usage* of the ACS. Questions pertaining to usage that guided this session included; 1) Will you continue using the ANC for your antenatal care? 2) Where the guidelines easy to follow while using the ACS? 3) Would you recommend other mothers to use the studio? 4) Did you enjoy using the studio? Following from the participant's engagement, a summary below echoes what most mothers found pertinent with the studio.

- Mothers pledged to continue using the studio in their antenatal care practices
- Guidelines were found useful
- Mothers promised to recommend other pregnant to use the studio
- User experience was good.

Generally, the overall perception on usage was positive

Mothers in the focus group were engaged to elicit specific aspects about usage of the studio, whether or not they would continue using the studio. We were interested in and asked specifically whether participants would recommend other expectant mothers to use the studio. Mothers described the studio as a platform that they would continue to use in their subsequent pregnancies. One mother in particular stated *"…however, using this platform has made me appreciate technology and now I feel I am not in this alone. This is something that I surely will continue to use in my subsequent pregnancies".* Another mother supplemented on the statement and rated her user experience as *"good".* Participants described some ACS services within certain suites very addictive. For example, one interviewee narrated:

> *'The chat service has become too addictive, I post an issue on my timeline for two reasons, first, to get information or help about the issue I have posted and second, also get to know people and build my network. I have been in position to grow a network of experienced mothers who have constantly shared with me a lot.'*

Many participants expressed that the guidelines were very easy to use and constantly referred to them in cases where some services seemed hard to use. Overall, the views of the participant seemed to be in line with those of others.

From the qualitative section of the evaluation questionnaire of expectant mothers, conventional content analysis was employed because it helped us to examine the nuances of the respondents' perceptions. These responses are arranged in a bullet list in order of frequency, that is, the number of times a response was mentioned by various respondents. From the researcher's perspective and interpretations made from the respondents' viewpoints, expectant mothers noted that:

- The ACS will improve their decision making during antenatal care should midwives and community health worker's online availability be guaranteed.
- Non-smart phone users advocated the studio to be designed to accommodate any type of phone.
- The ACS would make them more informed if the weekly messages are changed to being daily messages.
- Hospitals should encourage and facilitate midwives to use the studio as a way of reducing congestions in hospitals especially for cases that can be handled online.
- Other experts like gynaecologists need to be included on the list of care providers in the studio to enhance problem solving especially in areas that midwives and CHW can't handle.
- The studio can be a "second midwife" as a lot of information is exchanged more than what is got from antenatal care visits in hospitals therefore stakeholders should be incentivized to use it.
- The studio should have an offline version that will allow people to use it unlimitedly and expressively.

- It will be a good tool to narrow the gap between the expectant mothers, midwives and CHW's and therefore users should be encouraged to purchase smart phones or computers.
- The studio should include other aspects of maternal health like delivery care, immunization, birth control among others.
- Top administrators of the hospital should also be part of the studio users to monitor midwives and how they handle various issues of women.
- The studio should be integrated with the Ministry of Health system as a way of improving on health service delivery.

Evaluation with Midwives, Community Health Workers and Peers

A four day workshop was conducted with the midwives, community health workers and peers to assess the practical utility of the ACS and also as key stakeholders of the studio, to try and provide constructive feedback for enhancement of the studio (if any). This meeting registered 5 CHW, 7 midwives and 10 peer mothers. The workshop commenced on the 16th and ended on the 19th of May 2017. The research problem, objectives, findings and the purpose for which the studio was designed and implemented were discussed. A demonstration on how the artefact works was done by the researcher. All midwives, community health workers and peers were registered with the studio on day three and practical demonstration were done. Anyone registered as a midwife or community health worker could only view and interact with the emergency and engagement suite, while peer mothers could only use the engagement suite. For midwives and community health workers, emphasis was put on the emergency and engagement suite since all emergency alerts from expectant mothers came through the emergency suite and various communication whether one-on-one or group chat was done in the engagement suite. Midwives and community health workers were trained on how to respond to an emergency alert, how to engage in a conversation with a mother and how to respond to issues posted on the mother's timeline. Experiments were conducted to ascertain that the users had grasped the different services of the suites.

They were later left to use the studio for a period of four months after which a questionnaire was provided on the 13th of September 2017 which was assessing two things; usefulness and ease of use. Results in table. 6-6 represent evaluation results from community health workers, midwives and peers assessing usability and usefulness.

Table 6-6: Evaluation results assessing usability and usefulness of the ACS done by Peers, CHW and Midwifes

Usability	Mean	Mode	Std. Deviation
I find the ACS easy to use (E1)	3.96	5	1.255
Learning how to use ACS was easy for me (E2)	4.44	5	.641
It is easy to become skilful at using ACS (E3)	4.44	5	.847
The information was easily accessible (E4)	4.00	5	1.177
After learning the system, navigating was very easy (E5)	4.48	5	.753
The language was simple and easy to understand (E6)	4.41	5	.797
I did not always seek for help when using the studio (E7)	4.41	5	.797
I used the help function rarely (E8)	3.85	5	1.231
The guidelines stipulated for the use of the studio were very clear	4.00	5	1.177
Average Mean	**4.24**	**5.00**	**0.83**
Usefulness			
The open interaction with the users enhanced problem solving (U1)	4.41	5	.797
There is added value in using the studio (U2)	4.44	5	.801
I enjoyed using the studio (subjective satisfaction) (U3)	4.52	5	.643
Intervention to offer mothers help or advice was very helpful (U4)	4.41	5	.797
Information posted on the studio was very helpful (U5)	4.48	5	.753
Average Mean	**4.46**	**5.00**	**0.75**

Usability results in table. 6-6 with an average mean of 4.24 imply that peers, community health workers and midwives strongly agreed that they found the studio easy to use, information was easily accessible and that the language was simple to understand. This is further demonstrated with a standard deviation of 0.83 a figure below 1 which implies that the respondents did not significantly differ from each other in opinion. On usefulness, they noted that the studio enhanced problem solving and there was added value in using the ACS. This is reflected with (μ=4.46) implying that on average, majority of the respondents strongly agreed that the studio was useful. With a standard deviation of 0.75, the responses of these evaluators did not differ much from each other.

Qualitative Evaluation Responses

During the evaluation sessions with CHW's, peers and midwives, one focus group was conducted to check whether the respondents had any issues with using the studio and whether

there was any added value perceived. Using focus groups at this stage was intended to allow the researcher to probe for more details about the studio. As Fink (2006) rightly puts it, focus groups tap into subjective experiences and are an efficient way of collecting large amounts of data that describes, compares or explains a social phenomenon. 2 midwives, 2 community health workers and 3 peer mothers participated in this focus group discussion. Pertinent questions that guided this discussion included; 1) Do you find the studio easy to use? 2) Was the language easy to understand? 3) How often did you seek help while using the studio? 4)

Do you think the studio can help mothers augment their decision making practices? 5) Was there any added value in using the studio? 6) What challenges have you encountered? Information summarized below indicate views that were most common across the different participants.

- The studio was understandable both in language and navigability
- The ACS was useful to mothers in terms of information sharing
- Gap between mothers, CHW and midwives was narrowed
- Continuous engagement and interaction strengthened mother-midwife/CHW bond
- ACS can be used to enhance decision making
- Real-time training was possible

Challenges

- Bad Network
- Busy schedules on antenatal care days
- Many functionalities

Overall perception on the usability and usefulness of the ACS was positive

Participants were asked on how they perceived the studio in terms of usefulness and usability. If they thought in any way that the ACS added value to antenatal care practices. Although, all the findings discussed were surprisingly consistent among participants, it is instructive to note that interviewees acknowledged that some benefits were more or less important to an individual depending on their social and economic status. Many participants observed and emphasized the value and benefit of the studio in contributing positively to the lives of expectant mothers and theirs. These benefits, which were mentioned often by interviewees, include, constant communication and information sharing which improves trust among mothers and care providers, quick response to emergency situations and enhanced decision making. The

sentiment that was made by one of the participant (a CHW) was consistent with the views of other members in the focus group. He narrated that:

> *'We used to do weekly visits to pregnant women's home to assess their condition, advice and counsel them. Due to distance and other factors like weather, poor roads among others, checking on these women was very hard. With this ACS, I have been able to check on every pregnant woman in my cell every two days and my output is really tremendous. I am happy because I no longer travel long distances regularly, yet I check on them to find out how they are. Also the mothers are happy because I constantly check on them and in case they have a problem, they directly communicate to me which wasn't the case before. I am happy because I can do a lot more other things while fulfilling my duties as a care provider.'*

At the beginning, many of the participants had expressed fear for using the studio. Several interviewees explained that they as well as others were sceptical about using the ACS because it seemed big with many functionalities. Some members particularly those from less urban setting, took long to take advantage of the studio and iteratively mentioned the *"fear"* and *"mistrust"* they had to use the ACS and providing their only information to strangers. Also, midwives found it hard to use the studio because of their busy schedules. One midwife, whose sentiments echo the words of many, explained that:

> *'We are understaffed, and this health facility being a public facility that offers free maternity services, it serves a catchment of over 40KM in radius. And because most the residents around are of a low social status, they all end up here. So every day, on average we handle between 120-140 pregnant women who come for antenatal care services which begin at 9am up to 4pm. The only time I have to check on my phone is at the end of my shift. However, when I find a request from the mother, I immediately respond to it though sometimes it could be late. But that is where the community health worker comes in handy, because in most cases by the time I respond to the mother's request, she has already gotten help from the CHW.'*

"The studio was very direct to use" commented by one of the participants who emphasized that their major problem was not with the *usability* of the ACS, but with the fact that the *internet was not very stable.* Focus group participants noted the poor internet coverage brought about turbulence in the connection especially in remote areas. Some participants expressed that they

found it hard to connect because of the 2G network which was relatively slow in loading pages. It is important to emphasize that many interviewees certainly believed that the ACS would help a lot in mother's decision making but one of them stressed that this would only apply under two conditions; *"first, pregnant women recognized the potential that the studio has to improve on their lives; and second, utilizing and recognizing the care providers throughout their antenatal care cycle."*

Participants noted that the studio was a "*great innovation*" considering the fact that there was no practical evidence of the existence of a platform like this in Uganda and East Africa as a whole. Interviewees noted that the *"cutting-edge"* functionality of the studio that permitted them to exchange information seamlessly with mothers was not only *"innovative"* but very *"practical"* and *"relevant"* in their day-to-day antenatal care service delivery. One interviewee expressed her views in ways that were consistent with the opinions of others and she noted:

> *'In Uganda, many mHealth apps have been developed, many die in their infancy, while others are isolated and standalones, yet they don't offer dissimilar services. Many of these apps are "self-used" requiring no intervention from a care provider. One thing I have appreciated about this app is that is it "all-inclusive", midwives can monitor CHW's on an emergency case that was not responded to on time; hospitals can also evaluate the number of emergencies attended to, referred or disposed; chief midwives can monitor the performance of other midwives. This whole loop points to one thing "accountability". Which is very important in the health sector. I can strongly say that this studio was very beneficial to me.'*

6.4 Discussion of Results

At least from the viewpoints of the expectant mothers who participated in the evaluation, there was a general agreement that the studio was easy to use and useful. The usability was based on the fact that the studio was navigable, had intuitive interfaces and the content was understandable. Suffice it to say, mothers were satisfied because the studio was interactive, facilitative and invitational, an avenue that empowered their decision making practices while pregnant.

The usability of the studio was enhanced by the structured recipes and guidelines that guided the different users in navigating the studio. Evidence in table 6-4 and table 6-6 demonstrated that the user's effective utilization of the ACS was because of the guidelines that helped in the traversing of the studio with ease.

It was generally observed that the antenatal care studio facilitated routine antenatal care practices, enhanced antenatal care decisions, promoted a collaborative and synergetic environment among care providers and expectant mothers. Decisions enhanced by the ACS included; i) the decision to seek care from a care provider, ii) decision to go to the health facility with or without and emergency, iii) decision to adhere to recommended dietary needs, iv) decision to collaborate with other stakeholders, and v) the decision to seek information about antenatal care among others. Through one-on-one with care providers utilising the instant messaging service, group collaborations, text messages and online trainings, expectant mothers were in position to address many antenatal care decision making challenges. For example the evaluation results in table 6-3 had questions (U5, U7, U8 with means of 4.35, 3.98, and 3.79 respectively) specifically focused on the role of the ACS in enabling mothers make decisions to seek care in a hospital and use skilled care providers. The results indicated that majority of mothers agreed to have improved these decisions. This was further seen in the FGD were mothers agreed to have been empowered in decision making. Therefore, the inability to make decision which inhibited many women from accessing ANC services was addressed because mother's unconditionally interacted with the people who mattered in the antenatal care cycle, hence improving their decision making practices.

To reflect more on the usefulness of the studio, results indicated that CHW throughout using the studio played their interventional, informatory and advisory role and likewise midwives offered obstetric and emergency interventions to expectant mothers, something that was highly significant and vital.

Evaluation results indicated that the studio enhanced and supported group collaboration which were an engine in enabling mothers address antenatal care decision making challenges. The usefulness of the studio in bringing together different stakeholders to generate ideas and find solutions to ill-structured problems of expectant mothers in Uganda was a demonstration that the studio achieved its objectives.

The evaluation insights, both quantitative and qualitative indicated that the ACS was a useful platform because it facilitated sharing of ideas, insights and past experiences. In the studio,

each user had more "air time" that is, the time to contribute ideas and there was no undue pressure exerted on the users because all users were equal which eliminated user status incongruities. Additionally, the response time it took to get help from the CHW's and midwives had considerably reduced as mothers attested to this during the focus groups.

Evaluation results (μ =4.32) for the response (U3) and (μ =4.08) for the response (U4) in table 6-3 confirm that the studio played a very big role in strengthening the relationship between mothers and their care providers. This built synergy and users were better able to catch an error in a comment and reading a comment or an idea often gave creative stimulus which broadened the decision making space of expectant mothers.

In using the ACS as an information platform, the studio automatically recorded and stored all ideas or comments that were posted by the different users throughout a collaboration session hence not necessitating taking notes. This automated log of the discussions supported the development of personal repositories which became points of reference whenever a mother sought clarity on an issue that was earlier discussed. This was supported in table 6-3 where the response for question (U12) scored (μ =5.00). With the ACS, exchange of information, skills and knowledge contributed to a higher group satisfaction. Lack of information or knowledge was a major factor that influenced mother's decisions to utilize ANC services. But with the use of the ACS were different avenues were used to exchange information, results (U1, U2, and U10 with means of 3.97, 4.32, 4.27 respectively) implied that majority of the mothers became more aware of the different ANC practises.

There was an overarching concern among mothers about the delay in receiving care which greatly contributed to the non-attendance of antenatal care. However, responses from both the quantitative evaluation (U7=3.98 and U8=3.79) and the focus group discussions indicated that on average, care providers were responsive to emergencies and thus mothers were obliged to seek care.

On average, more than three quarters of the respondents (U13=4.37) liked using the ACS and because many used it to address individual-specific problems, this was indicative of how vital the studio was. Therefore, many who could not access ANC services because of distance reliably and conveniently used the ACS to handle issues that would rather require no physical presence in the hospital.

Referring to table 6-5, results on average indicated that mothers were using the studio and pledged to continue using it in their subsequent pregnancies. This can be attributed to the fact

that the ACS was easy to use and the benefits accrued from using it outweighed its non-usage. This was also evidenced with some pregnant women who had given birth during the evaluation period but continued to use the ACS especially on issues related to postnatal care.

Mothers during the evaluation expressed sincere gratitude especially those that did not have smart phones, because they received antenatal care messages making the ACS an "all-inclusive" platform. Receiving messages was not dependent on the type of phone one had.

Overall, results from the evaluation reflect a general consensus of the usability and usefulness of the studio. With a few challenges documented, a complete roll-out would be inevitable if; i) users are equipped with smart phones, ii) internet/data costs are subsidised for the users and care providers and iii) telecommunication infrastructural issues are addressed.

CHAPTER 7 – EPILOGUE

This chapter gives an overview of the overall research journey. Section 7.1 overview of the thesis, research questions and how they were addressed; section 7.2 presents the research approach; section 7.3 presents the research contribution; section 7.4 discusses the generalizability of the research; and 7.5 provides directions for future research.

7.1 Thesis Overview

This study started off by trying to understand decision making challenges expectant mothers face that hinder the effective utilization of antenatal care services. Different cases were explored and a number of pregnant women were interviewed in focus group discussions to try and understand the underlying issues affecting expectant mother's decision making practices. These interactions provided various viewpoints from mothers and a generic understanding leading into the design of the ACS offered a clear picture of the real issues affecting mothers. After a few iterations, the ACS design was instantiated and evaluated to ascertain usefulness, usability and usage. Results of the evaluation pointed to a general consensus among expectant mothers that the studio satisfied their needs and was easy to use.

The key research question this research sought to address was ***"How can antenatal care decisions among expectant mothers in Uganda be enhanced?"*** In order to answer this question one needed to first know the challenges mothers face during their routine antenatal care practices and the factors that influence their decision making to utilize antenatal care services. Hence, to effectively answer this, five specific questions were derived.

Question 1: What antenatal care challenges do expectant mothers face in Uganda?

In trying to understand this question, an insight into what antenatal care is and the various facets therein was discussed. This research question was intended to ascertain the main issues Ugandan mothers face in trying to access antenatal care services. These issues were discussed in chapter one and later expounded in chapter three (exploration). In chapter one, literature was reviewed which gave an overview into antenatal care challenges while in chapter three, an exploration into the different cases gave an in-depth understanding of the decision making challenges and key stakeholders in the antenatal care cycle. These challenges were found to be socially, politically and culturally inclined. However, also infrastructural and economic

challenges were noted. These challenges were found to be intrinsic (stemming from the mother) while others were extrinsic (external factors).

Question 2: What factors influence expectant mothers' decisions to utilize antenatal care in Uganda?

This question was partially answered in chapter two (literature review) and chapter three (exploratory study). In trying to understand this question, discussing decisions pertaining to antenatal care (chapter two) was imperative. It was noted during exploration that decision making among expectant mothers was not always rational, therefore depended a lot on heuristics. This was so because decisions involved multiple stakeholders and the problems were highly unpredictable and uncertain (Heracleous, 1994). Throughout literature and during exploration, it was discovered that expectant mothers made decisions in consultation with different stakeholders like community health workers, midwives, family and friends and their peers. Mothers hailed the importance of collaborating with community health workers and midwives in their decision making practices and this was evidently emphasized during exploration.

It was also discovered that expectant mothers made decisions based on emotions, beliefs and perception which highly impacted on the quality of decisions that they made. Making decisions based on sentiments, perception or belief without taking any rational precaution had an impact on the decision outcome, necessitating a need to enhance mothers' antenatal care decisions.

Question 3: How can a design leading to a studio be achieved?

This question was answered in chapter four. After gaining a generic understanding of the challenges and decision making practices of expectant mothers, an analysis was done to try and elicit requirements leading to the design of the studio. Different stakeholders were consulted through focus groups and interviews to try and refine the design. These included expectant mothers, PhD students of gynaecology and senior experts with vast experience in the field of maternal health. Also, lecturers, information systems experts, midwives and community health workers were consulted. At the end of these consultative meetings, a thorough breakdown and clustering of the requirements, five suites were derived, that is; emergency, self-care, engagement, training and messaging suites. The ACS design incorporated facets of people, technology and process working in a blended environment to enhance decision making. To further answer this question aptly, the design was hinged on the "ways-of" framework by

(Selingmann et al, 1989; Sol, 1988) which is comprised of the *way of thinking, way of working, way of modelling and way of governance.*

Question 4: How can a decision enhancement studio be instantiated to improve antenatal care decisions among expectant mothers in Uganda?

To address this question, a few instantiation considerations were put into account. Considering that the design reflected the integrability features, use of service oriented architecture was employed because of its capability to link all services to communicate with each other. The design was translated into a decision enhancement studio with a set of suites and services implemented using various programming languages. These languages enabled the implementation of functional, user and non-functional requirements to address expectant mother's needs. The user interfaces were comprised of different services that were connected to the database which acted as a central repository for all the information posted and shared on the studio. The antenatal care studio was a mobile web platform that was accessed both on a smart phone and on the computer to accommodate all kinds of users. The studio enhanced decision making practices of expectant mothers which greatly improved antenatal care outcomes by reducing response time, improving care given to mothers and enhanced interaction with care providers.

Question 5: How can a decision enhancement studio be effectively evaluated for perceived usefulness and usability?

The purpose of this question was to ascertain that the ACS fitted the purpose for which it was implemented. Using the technology acceptance model (Davis, 1989) and Keen and Sol's (2008) evaluation stance, the studio was evaluated against perceived usefulness, usability and usage. The ACS was presented to 62 mothers, 7 midwives, 5 community health workers and 14 peer mothers. As discussed in chapter 6, expectant mothers alluded to the fact the ACS achieved the following; reporting emergencies became easy, regular antenatal care visits were made with the help of the weekly messaging services that reminded them to go for care, decisions to seek care were enhanced due to the collaboration with midwives and community health workers, easy access to information especially through sharing in the engagement with various stakeholders. They also noted that the studio was navigable, understandable and intuitive making it easy to traverse through the different interfaces. Users appreciated the studio and pledged to continue using it in their subsequent pregnancies.

Throughout the evaluation, different techniques were used to engage the evaluators. These included but not limited to, one-on-one interviews, practical experimentation and focus group discussions among others. In light of the above, we conclude that the ACS is useful for enhancing decision making practices among expectant mothers, improves communication and collaboration among stakeholders and increases responsiveness to emergency situations.

As noted by Al-Mamary et al, (2014), successful adoption and use of information systems is hinged on various factors. These factors could be personal, technological, financial, and social among others. In relation to this research, the successful adoption and sustainable use of the ACS was based on the following attributes.

- Quality of the system and information. Like any other information system, the ACS possesses a number of attributes that are considered parameters against which quality of an information system is assessed. After the evaluation exercise, mothers concluded that the system was easy to use, easy to learn, flexible, reliable and intuitive as well as fast response time. Because the user satisfaction was generally rated highly, it is a strong reason for expectant mothers to sustainably adopt the ACS in their daily antenatal care practices.
- Self-efficacy. This refers to "the individual's belief that he or she has the skills and abilities to accomplish a specific task successfully" (Zhao, 2010). Many scholars (Saba, 2012; Bin et al. 2010; Ramayah & Aafaqi, 2004; Lopez & Manson, 1997) believe that self-efficacy positively influence usefulness and user satisfaction. Self-efficacy is measured using parameters such as: I can understand how the system works and I am confident I can learn how to use the system (Igbaria & Iivari, 1995). Basing on the evaluation results, these parameters were rated highly, hence reliable factors that drive the easy adoption and sustainable use of the ACS.
- User experience. Throughout the exploration and evaluation exercises, it was noted that expectant mothers had experience using mobile web technologies. Many of these users were using a couple of social media platforms and other apps on their mobile phones. This means that mothers can comfortably use and adopt the ACS in their decision making practices during pregnancy.
- Circumstantial factors. It should be noted that dire situations like the manifestation of danger signs as discussed in chapter 1, 2 and 3 require immediate medical attention if the baby or mother must survive. With the emergency component in the ACS, there is a likelihood for a mother to continuously use the ACS.

It is against this background, that a great number of expectant mothers who were engaged in the evaluation session devotedly used the studio in their day to day antenatal care practices giving us confidence of its sustainable use.

Basing on the discussion above, it can be concluded that the main research question was addressed by employing different philosophies, principles and strategies. Addressing specific research questions was in accordance to design science research principles. The first two questions specifically focused on the relevance cycle were problems affecting expectant mothers offered a starting point into the research which later offered a foundation for generating requirements. These requirements constituted a key ingredient in the design cycle. Drawing from the knowledge base, reference was made to the existing artefacts and processes in order to ensure that the ACS design and instantiation produced was unique and contributes to the knowledge base. Throughout this research, various theories and methods of design construction, implementation and evaluation were rigorously employed. The last three questions rotated around the design and the rigor cycle which iterated between the development of ACS and its evaluation. With a couple of iterations made to satisfy the requirements, it can be concluded that the objectives of this study were satisfactorily achieved.

7.2 Reflection on the Research Approach

Antenatal care decision making challenges faced by expectant mothers in Uganda are complex, ill-structured and sometimes unpredictable. Engaged scholarship (Van de Ven, 2007) and design science (Hevner et al, 2004) offered a starting point and guiding principles to decipher these issues and stimulate dialogue between the researcher and the stakeholders. This shaped the research problem, design, implementation and evaluation of the ACS. Design science as a particular stance of engaged scholarship, emphasises employing rigorous methods and iterations throughout artefact design, instantiation and evaluation.

This research took on a pragmatist stance that facilitated a practical application of skill to a domain specific problem by instantiating and testing it in a real human environment. The choice of pragmatism was the fact that several scholars (Gonzalez and Sol, 2012; Cole et al, 2005; Hevner et al, 2004; March and Smith, 1995) confirm its association with design science in an attempt to bridge science and practice. As emphasized by (Gregor and Hevner, 2013; Peffers et al, 2008; Hevner et al, 2004), the development of the ACS design and the prototype was a rigorous search process that drew from existing theories from the knowledge base to come up with a novel and unique product which was considered this study's major contribution. The

starting point of engaged scholarship and design science offered a collaborative inquiry which involved full and active participation of expectant mothers and other key stakeholders in the antenatal care cycle.

This study adopted the five phased approach of abductive reasoning (Sol, 1982) which started off by studying and analysing cases, abstracting, theory formulation, instantiation and evaluation of the ACS as discussed in chapter one. This step by step logical process offered a thematic decomposition of the research problem which clearly highlighted the inputs and the outputs of each phase.

To try and understand the decision making challenges and practices of expectant mothers, interviews and questionnaires were conducted with a total of 236 respondents who included pregnant women, peers, CHW and midwives from the different areas and health centres. Using multiple stakeholders offered an in-depth analysis into decision making challenges affecting expectant mothers in Uganda. Responses were generalized into the Ugandan context which subsequently offered ground for the requirements of the ACS. The requirements formed part of the studio design (see chapter 4) which was subsequently discussed using the "ways of" framework (Selingmann et al, 1989; Sol, 1988). The design was a highly collaborative and iterative process that engaged multiple stakeholders.

The antenatal care studio was implemented following the principles of service oriented architecture (Linthicum, 2017). Purpose was to ensure that design considerations were implemented to reflect practical utility of the studio in addressing antenatal care decision making challenges of expectant mothers in Uganda (see chapter 5).

Throughout this research, a couple of research instruments were used to gather information right from problem definition through requirements elicitation, design, instantiation, testing and validation. These included literature review, case studies and focus group discussions. This study was highly collaborative, participatory and involved a number of stakeholders in order to ensure collective inquiry and ownership. But also, issues that affect expectant mothers can't be solved in solitude, hence requiring the engagement of different people within the domain of antenatal care. This study focused on the principle of "inclusivity" which tries to include people who might otherwise be excluded (Winter and O'Row, 2010).

In light of the above insight, it can be concluded that design science is a paradigm that offers practical solutions to solve complex and ill-structured problems that do not have a clear procedural problem solving approach like antenatal care.

7.3 Research Contribution

This research followed and adopted the Engaged Scholarship paradigm in the format of Design Science (Van de Ven, 2007; Hevner et al. 2004). These approaches not only emphasize relevance but also stress the importance of research contributing to the knowledge base as well as to practice. March and Smith (1995) propose four general outputs as contribution to design science research and these include; constructs, models, methods and instantiations.

Throughout literature reviewed, there was no evidence of the applicability of decision enhancement services in antenatal care in Uganda yet many studies indicated the effective use of DE services in the different contexts in East Africa. Many such studies included; Poultry farm management (Tumwebaze, 2016), Water Asset Management (Katumba, 2016), Information System Risk Analysis (Mirembe, 2015); Business Process Agility (Amiyo, 2012); Miner Start-Ups (Habinka, 2012) among others. This study adopted the perspectives of decision enhancement services of Keen and Sol (2008) which is grounded on the theory of decision support system. DE offered a prescriptive insight on how to design and act and further emphasized the interrelationship between people, process and technology which offered guidance into developing the ACS design. The design described in chapter 4 is a major contribution to the concept of DES because it is unique and offers an empirical, logical and consistent description on how expectant mothers can use ACS to enhance their antenatal care decision making practices.

Gregor and Hevner (2013) posit that the construction of an artefact, its description in terms of design principles and technological rules are steps towards contributing to knowledge. Contribution in design science can be in form of a viable artefact or at more abstract level. The type of theory that formalizes knowledge in design science research is termed as design theory, which gives prescriptions for design and action (Gregor, 2006). The theory gives an explicit prescription for constructing an artefact (Gregor, 2006). Drawing from this research, the ACS design described in chapter 4 offers prescriptive knowledge in form of methods, techniques and principles that expectant mothers must use in order to enhance their antenatal care decision making practices. Reflecting on Gregor and Hevner's (2013) nascent design theory (level 2) and situated implementation of artefact (level 1) contribution types, the ACS design and instantiation strongly contributed to the body of knowledge in design science research. Hevner et al. (2004) emphasize that the artefact itself is a prime contribution of design science.

The ACS instantiation is a contribution because it is an operational software artefact with unique underlying recipes that describe how each suite work. At an abstract level, the design principles that demonstrate the necessary steps in the algorithm in pseudo code (*appendix H*) also contributes uniquely to the body of knowledge. March and Smith (1995) categorize algorithms as methods which are considered a contribution in design science research. Similarly, the ACS design described by Sol's "ways-of" framework demonstrates a new way of thinking, working, modelling and governance. It was established that the ACS design archetype together with its technological ability to mystify, evoke and enable interactions among stakeholders is innovative, aesthetic and collaborative, a clear and provable contribution in design science research. A series of rigorous iterations and engagement with various stakeholders during the design offered credibility that the ACS design contributed to a new theoretical and useful approach of enhancing antenatal care decisions among expectant mothers in Uganda.

This study also contributed towards achieving the sustainable development goal 5, which aims at ending preventable deaths by reducing maternal mortality to 40 or few deaths per 100.000 live births and promote and monitor healthy diets. One commonly recommended approach of improving maternal health is access to and improving antenatal care which the study provably achieved.

Various scholars in the field of medicine, information systems and other disciplines proposed and implemented various systems in the field of maternal health (*see chapter 2*). However, these mHealth applications offer fragmented services hence the benefits accrued from a single, siloed application cannot be matched with those of an integrated system. This offered a foundation to implement the antenatal care studio which integrates a couple of services to maximize the potential of mobile technology.

7.4 Generalizability of the ACS Design

One of the goals of design science is not only to try and address a specific problem at hand, but as an instance of more generic class of problems (Sein et al. 2011; Purao, 2002; Wall et al. 1992). Nunamaker et al. (1991) emphasizes that design science artefacts must be generalizable. Wieringa (2014) notes that design science research generalizes beyond the case level. The ACS design can be generalized to other aspects of maternal health like delivery care specifically during ante-partum and post-partum phases, postnatal care, new-born care and post-abortion management.

On generalizability, Wieringa (2014) provides examples of artefacts that were generalized to suit particular case scenarios. Important aspects to note about generalization but not limited to, is whether the artefact can deliver the same results when used by different people and, what design and technological aspects of the artefacts can be changed to suite the generalized scenarios. Generalization of a design theory states that the artefacts resulting from a theory can change or be changed but without changing the theory (Gregor and Jones, 2007). Generality is the hallmark of a theory, in essence, a theory should demonstrate a variety of ways it will be instantiated or changed, allow evolution, adaptation or learning of the results artefacts without affecting the theory (Vaishnavi & Kuechler, 2004). In relation to this research, the ACS instantiation aspects that require to be changed to fit the generalized contexts have been demonstrated below. The principles of the ACS design do not change while the instantiation changes. Once the following aspects of the instantiation are adjusted, then the studio can fit the generalized contexts.

1) Changing the guidelines of certain suites to suit the generalized contexts is paramount. This applies specifically to the self-care suite because the post-child self-care practices differ slightly from antenatal care practices.
2) In the self-care instantiation, the algorithm in the nutrition sub-suite requires adjustments to apply to other contexts. For example the dietary needs of a pregnant woman are different from those of a nursing mother. Hence, the algorithm that computes the dietary needs of the expectant mothers would require changing to suit the dietary needs of the nursing mother in postnatal care context.
3) Also, the algorithm in the weight management sub-suite would require changing to fit the generalized context. Postnatal BMI requirements differ from prenatal BMI requirements. In the generalized context, focus is on new-born care because the weight of the baby becomes more important and worthy attention than that of a nursing mother. Hence, the algorithm that computes BMI of a pregnant woman would require changing to an algorithm that computes the BMI of the baby.
4) In the messaging suite, the structure and content of messages would require changing because the information needs during delivery care, postnatal care, post-abortion and new-born care are different from the information needs in the antenatal care period.

The rest of the suites would not require changes in the instantiation because the services offered therein can also be extended to the generalized contexts.

Generalization of the ACS design was based on the following conditions:

- Decision making challenges. The challenges that limit access and utilization of antenatal care services in Uganda cuts across the entire maternal health sector. Several scholars (Dickson et al. 2013; Kabakyenga, 2012; Matsuoka et al. 2010; Kyomuhendo, 2003) in their work note that these challenges are not unique to antenatal care only and different strategies or solutions (Lee at al, 2009; UNFPA, 2007; Nabanoba, 2005) focused to address these challenges were intended for the entire maternal health sector. Basing on this, the ACS can be generalized beyond the antenatal care context.
- Decision making practices. These practices in antenatal care revolve around nutrition and diet, management of emergency obstetric cases, weight and preeclampsia management, seeking medical help among others. In comparison to maternal health, some of these practices are equally experienced during delivery care, postnatal care, new-born care and post-abortion management though the context of application may slightly differ. In light of this, the ACS design may be generalized to suite these contexts.
- Stakeholder involvement. The maternal health sector in general is a multi-stakeholder domain. These stakeholders include midwives, gynaecologists, community health workers and nurses among others. Therefore the applicability of the ACS design fits very well to the specific areas of delivery care, post natal care, new-born care and post-abortion management.

To emphasize on the issue of generalizability, mothers who had given birth during the evaluation period continued to use the studio to contact their midwives and community health workers, an indication that the studio extended its applicability in their post-antenatal period.

In conclusion, whereas delivery care, postnatal care, new-born care and post-abortion management are areas that can be generalized to the ACS design, the applicability of the design needs to first be evaluated to these contexts to ascertain its usefulness, usability and usage

7.5 Directions for Future Research

This research offered a description of the antenatal care decision making challenges that expectant mothers face during pregnancy. The design and instantiation as a way of contributing to theory and practice was also presented. However, the constraints of time, money and human

resource capacity among others limited the scope of the study. As a result, the study recommends the following as areas for further research.

1) Employing usability guidelines for the antenatal care studio doesn't guarantee sustainable use of the artefact. Therefore, there is need to further explore usability of the studio over a lengthy period of time to understand what the users want, usability challenges and the context of use in order to develop more specific approaches for sustainable use of the studio.
2) The antenatal care studio was generalized to other aspects of maternal health, that is, delivery care, postnatal care, new-born care and post-abortion management. Evaluating the applicability of the studio to these specific contexts needs to be explored further in order to ascertain the usability and usefulness of the studio to those contexts.
3) Key players of the studio were midwives who provided an interventional, informational and advisory role to the mothers. However, it should be noted that certain conditions are beyond the care of the midwife. Therefore, this research recommends the inclusion of the gynaecologist who, because of their skill, offer much more specialized and comprehensive care in the field of gynaecology which could broaden the decision making spectrum of mothers.
4) Since many users of the system complained about the data/internet charges, further research should look into providing an offline version to increase on adoption and sustainability.

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APPENDICES

Appendix A - List of Acronyms

ACS	Antenatal Care Studio
ANC	Antenatal Care
API	Application Programming Interface
BMI	Body Mass Index
CHW	Community Health Worker
DE	Decision Enhancement
DES	Decision Enhancement Services
DSR	Design Science Research
DSRIS	Design Science Research in Information Systems
EmOC	Emergency Obstetric Care
FANTA	Food and Nutrition Technical Assistance
GSMA	Global System for Mobile Communication Association
HIV/AIDS	Human Immune Virus / Acquired Immune Deficiency Syndrome
ICF	International Classification of Functioning, Disability and Health
IS	Information Systems
JHPIEGO	Johns Hopkins Program for International Education in Gynaecology and Obstetrics
MAMA	Mobile Alliance for Maternal Action
MCCM	Mother and Child Care Module
MDGs	Millennium Development Goals
MoFED	Ministry of Finance and Economic Development
MoFPED	Ministry of Finance Planning and Economic Development
MoH	Ministry of Health
MoTECH	Mobile Technology for Community Health
NPA	National Planning Authority
ORM	Object Relational Mapper
PATH	Program for Appropriate Technology in Health
PHP	Personal Home Page

SDGs	Sustainable Development Goals
SMS	Short Message Service
UBOS	Uganda Bureau of Statistics
UCC	Uganda Communications Commissions
UDHS	Uganda Demographic Health Survey
UN	United Nations
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children Fund
WHO	World Health Organization

Appendix B - Questionnaire for the Survey on Antenatal Care

Dear Participant,

This questionnaire is aimed at finding out the decision making challenges mothers face during antenatal care. Decision enhancement aims at enhancing decision making processes through professional practices that fuse human skills and technology; bringing together the best of executive judgment and experience with the best computer modelling, information management and analytic methods and whereas performance measurement monitors and reports progress of pre-established goals.

Literature provides a couple of problems ranging from direct and indirect; personal, communal and organizational; informational, social and cultural problems. This exercise serves to validate what literature has already documented. You have been selected randomly and the information that you provide is likely to improve on antenatal care decision making. I request that you respond to the questionnaire frankly and honestly. The information you provide will be for academic purposes only and will be treated with utmost secrecy and anonymity.

Thank you very much for your time and cooperation.

Namatovu Hasifah K.

(PhD Student University of Groningen, the Netherlands)

SECTION A: Demographics

1. Highest education level
   a) Primary
   b) Secondary
   c) Tertiary
   d) University
2. Age
   a) 18 – 25 years
   b) 36 – 45 years
   c) 26 – 35 years
   d) 45 - 50

SECTION B: General Information

1. Which district do you come from?
   Kampala ☐ Jinja ☐

2. What status are you? (Tick where appropriate)
   Pregnant Woma☐ Mother with baby less than 2 yea☐

3. How many children do you have?
   None ☐ 1☐ 2☐ 3☐ Above 4☐

4. How do you always get information concerning antenatal care?

Radio ☐ TV ☐ Print Media ☐ Internet ☐ None ☐

5. Who is your major source of antenatal care information?

Peer mothers ☐ Nurses/Midwi ☐ ☐ily ☐

Community Health workers My previous experience ☐

6. What kind of information would aid your decision making?

Nutritional information ☐ Information on Danger Si ☐
Lab test information ☐ ☐
Information on Preeclampsia ☐ ☐
☐ Types of services offered ☐
☐

Any other information, please specify

……
……
……
……
……

7. a) Are you solely responsible for making your own decisions?

Yes ☐ No ☐

b) If no, who is?…….

……

…….

c) Why?

……
……
……
……..

8. Which of the following circumstances would trigger your decision making to seek care?

☐

No foetal movement Drastic change in w ☐ t
Severe Abdominal pain ☐ Severe headache ☐
Blurry vision ☐ Reduced urine ☐
Symptoms of labour ☐ Vaginal bleeding ☐
Dizziness ☐ Persistent vomiting ☐
Breaking of the water ☐ High fever ☐
Sudden swelling of the in face, hands and e ☐
☐
☐

Contraction before 37 weeks
None

Any other information, please specify
……
……
……
……
……..

9. Are these any of the challenges that prohibit you from accessing antenatal care services?

Lack of information regarding matern ☐ Lack of transport ☐
services

Long distance ☐ Inadequate services ☐

If there any other challenges, please specify
……
……
……
……
……..

SECTION C: Antenatal Care

1. a) Do you always go for Antenatal care services (ANC)?
   Yes ☐ No ☐
   b) If not, why?
   .....
   .....
   .....
   .....
2. How many times did you go for ANC on your last pregnancy?
   1 ☐ 2-3 ☐ Above 4 ☐ None ☐
3. In my last pregnancy, I gave birth in a hospital
   Yes ☐ No ☐
4. Have you ever been assisted through delivery without a presence of a skilled birth atten ☐ ☐
   Yes No

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
In my opinion, I know the importance of antenatal care during pregnancy	1	2	3	4	5

I am fully aware of the services involved in antenatal care	1	2	3	4	5
Not going for ANC could be fatal for the mother and her unborn baby	1	2	3	4	5
In my opinion, preventive services which include iron and folic are important during and after pregnancy	1	2	3	4	5
Emergency					
In my opinion, I am aware of the danger signs of pregnancy	1	2	3	4	5
I know the importance of emergency services during pregnancy	1	2	3	4	5
It is important to seek immediate medical help in case of an emergency	1	2	3	4	5
If given all the necessary information, I will give birth from a hospital	1	2	3	4	5
Health Facilities					
I know the health facilities to go to for ANC	1	2	3	4	5
I am aware of the services offered at different health centres	1	2	3	4	5
Blood Pressure					
I know what BMI is	1	2	3	4	5
I am usually told my BMI when I go for ANC	1	2	3	4	5
I usually take my weight measurements whenever I go for ANC	1	2	3	4	5
I can use the BMI readings to know when I am overweight	1	2	3	4	5
I can use the BMI readings to know when I am underweight	1	2	3	4	5
I can use the BMI readings to know when I am of normal weight	1	2	3	4	5
In my opinion, I know the dangers of being over-weight before and during pregnancy	1	2	3	4	5
In my opinion, I know the dangers of being under-weight before and during pregnancy	1	2	3	4	5
Preeclampsia					
In my opinion, I am aware of the causes of pre-eclampsia	1	2	3	4	5
I am aware of the symptoms of pre-eclampsia	1	2	3	4	5

If I get symptoms of preeclampsia, I immediately seek medical attention					
Pre-eclampsia can lead to eclampsia	1	2	3	4	5
In my opinion, I am aware of the dangers associated to pre-eclampsia	1	2	3	4	5
In my opinion, I know the importance of taking blood pressure measurements during and after pregnancy	1	2	3	4	5
Nutrition					
In my opinion, I know the importance of a balanced diet during and after pregnancy	1	2	3	4	5
In my opinion, I know the foods permissible to be consumed by pregnant women	1	2	3	4	5
I know when to consume certain foods	1	2	3	4	5
I know the five major food groups that a pregnant woman should have on her diet during pregnancy	1	2	3	4	5
I know the importance of each food group to a pregnant woman	1	2	3	4	5
I am aware of the standard serving to be eaten daily for each food group	1	2	3	4	5
Self-Diagnosis					
I know the cause of most symptoms experienced during pregnancy	1	2	3	4	5
Collaboration					
I know the importance of engaging with a midwife during pregnancy	1	2	3	4	5
I know the importance of engaging with a community health worker during pregnancy	1	2	3	4	5
I believe in continuous communication with medical professionals during pregnancy	1	2	3	4	5

SECTION D: Use of ICT technology

1. a) Do you have a mobile phone?

   Yes ☐ No ☐

   b) Is it a smart phone?

   Yes ☐ No ☐

2. Would you be comfortable receiving information related to pregnancy on your mobile phone?

   Yes ☐ No ☐

3. Do you use any ICT technology for decision making when utilising maternity care services?

   Yes ☐ No ☐

   If yes, please specify

ICT Technology	**Purpose**

4. Would you buy a smart phone if you confirmed that it can add value during pregnancy?

   Yes ☐ No ☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
In my opinion a mobile phone would be a better way to communicate to health workers					

Thank you for your cooperation in completing this questionnaire

Appendix C – Interview Questions with Focus Groups (Expectant Mothers)

1) What challenges do you face during antenatal care?

2) What social, human, political or environmental factors influence your decision making?

3) Do you think a combination of midwives and CHW's would be a nice recipe to enhance antenatal care information access and decision making?

4) How best would you want to access antenatal care services?

Appendix D – ACS Evaluation Questionnaire for Expectant Mothers

Dear Participant,

This questionnaire is aimed at assessing the extent to which the antenatal care studio fit the purpose for which it was instantiated. Decision enhancement aims at enhancing decision making processes by bringing together different stakeholders with the best computer modelling, information management and analytic methods.

This exercise serves to validate the usability and usefulness of the artefact in enhancing ANC decisions among expectant mothers coupled by assessing usage. You have been selected randomly and the information that you provide is likely to improve on decision making among pregnant women in Uganda. I request that you respond to the questionnaire frankly and honestly. The information you provide will be for academic purposes only and will be treated with utter secrecy and anonymity.

Thank you very much for your time and cooperation.

Namatovu Hasifah K.

(PhD Student University of Groningen, the Netherlands)

SECTION A: Demographics

3. Sex
   a) Male b) Female
4. Highest education level attained
   c) Primary c) Tertiary
   d) Secondary d) University
5. Age
   d) 18 – 30 years c) 30 – 50 years
   e) 50 – 65 years d) Above 65years

SECTION B

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Usefulness (PU)					
ACS improved my knowledge on antenatal care (U1)					
ACS improved my knowledge on danger signs, nutrition, and preeclampsia (U2)					
ACS improved and strengthened my relationship with midwives (U3)					
ACS improved and strengthened my relationship with community health workers (U4)					
ACS made it easier for me to remember to go for antenatal care through messages sent (U5)					
I was able to keep track of my diet in order to improve on my nutrition (U6)					
ACS improved the emergency response time because CHW responded immediately on receiving the emergency alert (U7)					
ACS quickened my decisions to seek care in the event of a warning sign or signs of preeclampsia surfaced (U8)					
I have been able to get solutions to problems quickly through engaging medical personnel, CHW and peers (U9)					
Using the ACS helped me better understand likely problems to experience during pregnancy therefore act upon them (U10)					
There is added value in using the studio (U11)					
I enjoyed using the system (subjective satisfaction) (U12)					
Ease of Use (PE)					
I find the ACS easy to use (E1)					
Learning how to use ACS was easy for me (E2)					
It is easy to become skillful at using ACS (E3)					
The information was easily accessible (E4)					
Navigating the ACS was very easy (E5)					
The language was simple and easy to understand (E6)					
I did not always seek for help when using the studio (E7)					
I used the help function rarely (E8)					

Evaluation Questionnaire for the Expectant Mothers

Please provide any other information on how the antenatal care studio reflected on functionality, usability, reliability, performance and supportability.

……

……

……

Thank you for your cooperation in completing this questionnaire

Appendix E – Interview Questions with Focus Groups (Expectant Mothers)

The usability questions that guided the discussion included;

1) Do you find the ACS easy to use?

2) Was is it easy to find what you wanted?

3) Was the language understandable?

4) What challenges did you find while using the ACS?

The questions on perceived usefulness that guided this discussions included;

1) Did the ACS improve your knowledge of antenatal care?

2) Did the ACS improve your relationship with the midwives and CHW's?

3) Did the ACS improve your frequency of visiting the health center?

4) How did the ACS improve on your decision making practices?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Usage (U)					
I will continue to use the studio during my antenatal care practices					
Usage of the ACS did not reflect the right context of antenatal care practices					
The guidelines were easy to follow while using the ACS					
I would recommend other mothers to use this studio					
I enjoyed using the studio (subjective satisfaction)					

Questions pertaining to usage that guided this session included;

1) Will you continue using the ANC for your antenatal care?

2) Where the guidelines easy to follow while using the ACS?

3) Would you recommend other mothers to use the studio?

4) Did you enjoy using the studio?

Appendix F – ACS Evaluation Questionnaire for Peer Mothers, CHW and Midwives

Dear Participant,

This questionnaire is aimed at assessing the extent to which the antenatal care studio fit the purpose for which it was instantiated. Decision enhancement aims at enhancing decision making processes by bringing together different stakeholders with the best computer modelling, information management and analytic methods.

This exercise serves to validate the usability and usefulness of the artefact. You have been selected randomly and the information that you provide is likely to improve on decision making among pregnant women in Uganda. I request that you respond to the questionnaire frankly and honestly. The information you provide will be for academic purposes only and will be treated with utter secrecy and anonymity.

Thank you very much for your time and cooperation.

Namatovu Hasifah K.

(PhD Student University of Groningen, the Netherlands)

SECTION A: Demographics

6. Sex
   b) Male b) Female
7. Highest education level attained
   e) Primary c) Tertiary
   f) Secondary d) University
8. Age
   f) 18 – 30 years c) 30 – 50 years
   g) 50 – 65 years d) Above 65years

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Usefulness (PU)					
ACS improved my knowledge on antenatal care (U1)					
The open interaction with the users enhanced problem solving (U2)					
There is added value in using the studio (U3)					
Ease of Use (PE)					
I find the ACS easy to use (E1)					
Learning how to use ACS was easy for me (E2)					
It is easy to become skillful at using ACS (E3)					
The information was easily accessible (E4)					
Navigating the ACS was very easy (E5)					
The language was simple and easy to understand (E6)					
I did not always seek for help when using the studio (E7)					
I used the help function rarely (E8)					
Usage (U)					
I will use the studio during my antenatal care practices					
Usage of the ACS did not reflect the right context of antenatal care practices					
The guidelines are easy to follow while using the ACS					
I enjoyed using the studio (subjective satisfaction)					

Please provide any other information on how the antenatal care studio reflected on functionality, usability, reliability, performance and supportability.

……
……
……
……
……

Thank you for your cooperation in completing this questionnaire

Appendix G – Interview Questions with Focus Groups (Peer Mothers, CHW and Midwives)

Pertinent questions that guided this discussion included;

1) Do you find the studio easy to use?

2) Was the language easy to understand?

3) How often did you seek help while using the studio?

4) Do you think the studio can help mothers augment their decision making practices?

5) Was there any added value in using the studio?

6) What challenges have you encountered?

Appendix H – Pseudo Code for Emergency and Self-Care Suite

Geo Location (Emergency Suite)

The system uses the pregnant mother's latitude and longitude to find their location on the map.

The following happens to find location:
*check if **geo-location** is active in the user's browser*
*if **geo-location** is disabled,*
request user to enable access to their current location
*then pick **latitude** and **longitude***
else if geo-location is enabled,
*pick **latitude** and **longitude***

*send request to Google Maps API by parsing the latitude and longitude to Google Maps URL **endpoint***
get json response from the request
*parse **jsondata** response*
*If the **jsondata** data is invalid, return empty array*
*else encode the **jsondata** response*
*call Google Map **methods** by parsing the to find a specific address*
for example: country - call google_getCountry(jsondata), province - google_getProvince(jsondata), city - google_getCity(jsondata), street - google_getStreet(jsondata)
return address

Nutrition Sub-Suite

*get input value for date of the record: set **date***
*get input value for food group: set **food_group***
*get input value for food stuff: set **food_stuff***
*get input value for quantity: set **quantity***
*get input value for measurement: set **measurement***
find the nutrient content of the meal by finding the equivalent of the input quantity to standard quantity based on the input measurement
if 1 measurement is equal to standard nutrient content
*then input quantity is equal to standard nutrient content multiplied by input quantity: set as **nutrient_content***
save data

The nutritional needs of the pregnant woman depends on the standard serving and standard measurement. Standard serving determines the least or most number of times a pregnant woman is supposed to consume a given food group.

For servings:
*group meals by **food_groups***
*count number of times a given food group has been recorded for a given **date**: set as **food_group_count***
*for each **food_group**, use standard serving*
*if **food_group_count** is less than the standard serving, display warning - "notify*

pregnant woman to consume more of the food group a day"
else display okay - "encourage pregnant woman to keep up with the serving"

For measurements:
*group meals by **food_groups and food_stuff***
*get saved **nutrient_content** for a given meal*
for each meal, use standard measurement
*if **nutrient_content** is less than the standard content, display warning - "notify pregnant woman to consume more of the food stuff in an appropriate measurement a day"*
else display okay - "encourage pregnant woman to keep up with the measurements"

Appendix I – Focus Group Evaluation Sessions

Concluded Session with the Midwives at Kisenyi Health Centre IV

Session with Community Health Workers of Walukuba at Jinja

Appendix J - Stakeholders and Experts Involved in the Study

Activity	Expert	Sample	Page
Problem Definition	Expectant Mothers	164	37
Theory Formulation	Expectant Mothers	10	60
	Midwives & CHW	5	61
	Info. Systems Experts	4	61
	Lecturers	4	62
	Phd Students of Gynaecology	3	62
Instantiation	Programmers (though not documented in the report)	2	
Evaluation	Midwives	7	108
	CHW	5	108
	Expectant Mothers	62	108 - 121
	Peer Mothers	14	108

Appendix K – Research Activity Timelines

No	Activity	From	To
1.	PhD Start Date	Feb 2014	
2.	Problem Definition	Mar 2014	Mar 2015
3.	Theory Formulation	Apr 2015	Dec 2015
4.	Instantiation of the Artefact	Feb 2016	Apr 2017
5.	Evaluation of the Artefact	May 2017	Sep 2017
6.	Thesis Compilation	Sep 2017	Dec 2017
7.	Thesis Submission	Dec 2017	

SUMMARY

Antenatal care attendance and access to ANC services is still a very big problem among expectant mothers of Uganda especially those from rural and resource constrained communities. Yet, ANC is an avenue for receiving information about pregnancy and child birth, informs women about danger signs and directly improves the survival and health of babies. Therefore, women not utilizing ANC are at a very high risk of experiencing poor pregnancy outcomes. WHO states that it is the right of every pregnant woman to have access to these services and recommends that every pregnant woman attends a minimum of four antenatal care visits as a way of reducing improving pregnancy outcomes.

This study employed design science as a stance of engaged scholarship to try and understand the problem domain. Design science offers a better and structured approach of dealing with ill-structured problems and presents a chronological order into finding solutions to such complex problems.

It was revealed both in literature and exploration that there are a number of challenges that limit the access to ANC services in Uganda. These challenges include but not limited to; social, cultural and political barriers; lack of information and absence of emergency obstetric care. Decision making among expectant mothers is influenced by a number of factors which include; cultural inclination, inability to afford cost of care, lack of information, role of spouse and family members, lack of autonomy by most expectant mothers to make decisions that affect their lives among others. Hence, the key research question in this study, was *"How can antenatal care decisions among expectant mothers in Uganda be enhanced?"* This study focused on enhancing antenatal care decisions thus, the research question offered a starting point to delve into decision making practices of expectant mothers and trying to understand the environment within which they operate.

It was further revealed that mothers operate in a multi-stakeholder environment therefore, their decisions are largely influenced by many stakeholders. These stakeholders include peer mothers, community health workers, midwives, spouses among others. During decision making, it was discovered that expectant mothers employ logic and heuristics in an adaptive way to deal with certain conditions. This was commonly seen in cases of emergency were expectant mothers did not have the time to apply rationality in decision making but rather use

little information in the shortest time possible to guide decision making. These findings revealed the complex environment within which expectant mothers operate.

From the above insights, a generic understanding leading to the ACS design was realised. The design was grounded using the using the notion of decision enhancement (Keen and Sol, 2008) and the "*ways of"* framework offered a chronological description into the way of thinking, working, modelling and governance of the ACS design. This was followed by instantiating the design into the *Antenatal Care Studio*. Reflecting on the kind of environment expectant mothers operate in, DE was the most viable approach to use in the context of this study because it offers a virtual environment where multiple stakeholders can interactively collaborate and share information on decisions that matter.

The ACS has five suites with different services embedded in each suite and guidelines that demonstrate how the studio works. These suites include; the emergency suite which enhances decision related to emergency response. This suite has the obstetric care service that deals with the identification and responding to emergency situations; and the facilities service that helps mothers identify and locate the nearest hospital from the their physical location. The self-care suite enhances expectant mother's decisions concerning day-to-day management of her pregnancy. This suite has the nutrition and weight management service which enhances decisions with regard to foods permissible for pregnant woman, quantity, when and how to feed. However for weight management, decisions enhanced could range from seeking professional care to engaging in healthy lifestyle activities should the BMI be above or below the normal. The engagement suite is a collaborative environment where multiple stakeholders within the antenatal care cycle interact and share experiences, ideas and insights. The engagement suite enables real-time interaction between the different participants which enables mothers make fast and informed decisions. The training suite offers an avenue where expectant mothers can converge and have real-time sessions with midwives on issues pertaining to antenatal care. Lastly, the messaging suite enables every expectant mother registered with the studio to receive antenatal care information in form of text messages every week. Based on the prevailing condition, this suite also allows the creation of custom-made messages that are sent out as alert to mothers. This suite also has an AC reminder service that enables a mother to create events in the calendar such as ANC appointments. All these suites have recipes that indicate how each suite can be used.

From implementation, the ACS was evaluated in a practitioner-oriented environment using experimentation and case study demonstration to ascertain its usage, usefulness and usability. Stakeholders that participated in the evaluation sessions were expectant mothers, peers, community health workers and midwives. Focus group discussions and structured interviews were used to get a better understanding on how the users perceived the studio. From the evaluation, it was revealed that the studio facilitated routine antenatal care practices, enhanced antenatal care decisions and promoted a synergetic and collaborative environment among care providers and expectant mothers. Essentially, the studio was very useful because mothers who gave birth during the evaluation period continued to use the studio to engage with care providers on postnatal care issues. Overall, results were positive implying that the users found the ACS useful which can be confirmed by its continued use in the post-evaluation and post-pregnancy period.

The ACS design and instantiation contributed both to knowledge in design science research and to practice. This study also contributed towards achieving the sustainable development goal 5, which aims at ending preventable deaths by reducing maternal mortality to 40 or few deaths per 100,000 live births through improving access to antenatal care services. The ACS was generalised beyond antenatal care to other contexts of delivery care, new-born care, postnatal care and post-abortion management. For the ACS to fit well with the generalised contexts, changing the algorithm of the nutrition and weight management service is highly recommended.

Samenvatting

Prenatale zorg is een groot probleem onder aanstaande moeders in Oeganda en vooral voor diegenen die in afgelegen en van voorzieningen verstoken gebieden wonen. Prenatale klinieken lichten vrouwen voor over zwangerschap en bevalling; ze informeren vrouwen over waarschuwingssignalen en vergroten rechtstreeks de overlevingskans en gezondheid van baby's. Daarom hebben vrouwen die geen gebruik maken van prenatale klinieken een grote kans dat de zwangerschap niet goed verloopt. De WHO stelt dat elke zwangere vrouw recht heeft op toegang tot deze voorzieningen. Het advies luidt dat elke zwangere vrouw ten minste vier keer de kliniek bezoekt om zo de kans op een goede afloop van de zwangerschap te vergroten.

Uitgaande van engaged scholarship heeft deze studie design science als onderzoeksaanpak genomen.

Uit literatuur en verkennend onderzoek blijkt dat er een aantal factoren zijn die de toegang tot prenatale klinieken in Oeganda belemmeren. Belemmerende factoren zijn onder andere sociale, culturele en politieke barrières, maar ook een gebrek aan informatie en het ontbreken van acute obstetrische zorg. De besluitvorming van aanstaande moeders wordt beïnvloed door verschillende factoren waaronder culturele achtergrond, gebrek aan financiële middelen, gebrek aan informatie, de rol van de echtgenoot en familieleden, het gebrek aan autonomie waardoor de meeste aanstaande moeders onder andere niet zelfstandig over hun leven kunnen beslissen. De belangrijkste onderzoeksvraag luidt daarom: 'Hoe kan de besluitvorming rondom prenatale zorg onder aanstaande moeders in Oeganda worden verbeterd?' De onderzoeksvraag biedt een startpunt om dieper in te gaan op het besluitvormingsproces onder aanstaande moeders en om te proberen de omgeving waarin zij zich bevinden beter te begrijpen.

Gaandeweg is duidelijk geworden dat moeders zich bevinden in een omgeving met vele belanghebbenden die hun beslissingen grotendeels beïnvloeden. Onder deze belanghebbenden bevinden zich bijvoorbeeld collega-moeders, wijkverplegers (community health workers), verloskundigen, echtgenoten. Om tot een besluit te komen, zo blijkt, gebruiken aanstaande moeders logica en heuristiek in een adaptieve vorm. Dit kwam vooral naar voren bij spoedgevallen waar aanstaande moeders geen tijd hadden om rationele beslissingen te nemen maar in plaats daarvan weinig informatie in een zo kort mogelijke tijd gebruikten om tot een

besluit te komen. Deze bevindingen laten de complexiteit van de omgeving zien waarin de moeders zich bevinden.

Bovenstaande inzichten hebben geleid tot een beter begrip van de problematiek, wat uiteindelijk heeft uitgemond in het ontwerpen van de *Antenatal Care Studio* (ACS). Het uitgangspunt van het ontwerp is decision enhancement (Keen en Sol, 2008). Het uiteindelijke resultaat is de implementatie van de ACS. De ACS biedt een virtuele omgeving waar meerdere belanghebbenden interactief kunnen samenwerken en informatie kunnen uitwisselen over belangrijke beslissingen.
De ACS heeft vijf suites waarin verschillende diensten geïmplementeerd zijn en die instructies bevatten over hoe de studio werkt. De *emergency suite* moet de besluitvorming rondom acute hulpvragen verbeteren. Deze suite bevat de obstetrische zorgdienst die spoedgevallen identificeert en hierop reageert en de facilitaire dienst die moeders helpt om het dichtstbijzijnde ziekenhuis te identificeren en lokaliseren vanaf de plek waar zij zich op dat moment bevinden. De *self-care suite* bevordert de besluitvorming rondom algemene zaken die de zwangere vrouw aangaan. Deze suite bevat de dienst voeding en gewichtsbeheersing, die de besluitvorming betreft rondom de geschikte voeding voor zwangeren, de juiste hoeveelheid, frequentie en wijze van voedselopname. Besluitvorming rondom gewichtsbeheersing kan gaan over het zoeken van professionele hulp of het kiezen voor een gezondere leefstijl als de BMI te laag of te hoog is. De *engagement suite* is een samenwerkingsomgeving waarin verschillende belanghebbenden binnen het prenatale zorgsysteem met elkaar communiceren en ervaringen, ideeën en inzichten uitwisselen. Deze suite maakt realtime-interactie mogelijk tussen de verschillende deelnemers, waardoor moeders snelle en geïnformeerde beslissingen kunnen nemen. De *training suite* biedt een plek waar aanstaande moeders samen kunnen komen en realtimesessies met verloskundigen kunnen bijwonen over allerlei zaken die te maken hebben met prenatale zorg. Als laatste zorgt de *messaging suite* er voor dat alle aanstaande moeders die in de studio geregistreerd staan elke week per sms informatie krijgen over prenatale zorg. Via deze dienst kunnen ook persoonlijke berichten gestuurd worden, afgestemd op de moeder en haar conditie. Deze suite heeft ook een herinneringsservice waarmee de moeder een evenement kan creëren in haar agenda, zoals een afspraak bij de prenatale kliniek. Al deze suites bevatten instructies over hoe ze kunnen worden gebruikt.
De ACS is uitvoerig getest door middel van praktijkexperimenten om vast te stellen hoe de studio te gebruiken is en of deze bruikbaar en gebruiksvriendelijk is. Belanghebbenden die aan de evaluatie hebben deelgenomen zijn aanstaande moeders, collega-moeders, wijkverplegers

(community health workers) en verloskundigen. Om beter te begrijpen hoe gebruikers de studio hebben ervaren, zijn focusgroepdiscussies en gestructureerde interviews ingezet. Uit de evaluatie is gebleken dat de studio routinematige prenatale zorg mogelijk heeft gemaakt, de prenatale besluitvorming heeft verbeterd en dat deze een synergetische houding en samenwerkingsomgeving onder hulpverleners en aanstaande moeders heeft bevorderd. Het belangrijkste is dat de studio erg nuttig is gebleken omdat moeders die tijdens de evaluatieperiode bevielen gebruik zijn blijven maken van de studio om met zorgverleners in contact te komen over zaken rondom de postnatale zorg. Over het algemeen waren de resultaten positief, wat bleek uit het feit dat de gebruikers de ACS zijn blijven gebruiken, ook na de evaluatie- en zwangerschapsperiode.

Het ontwerp en de implementatie van de ACS droegen bij aan de kennisbasis in design science en in decision enhancement. Deze studie heeft ook bijgedragen aan het Duurzame Ontwikkelingsdoel (SDG) 5, dat tot doel heeft om de moedersterfte die kan worden voorkomen, te voorkomen. Door de toegang tot prenatale zorg te verbeteren kan de moedersterfte worden gereduceerd tot 40 of minder doden per 100.000 levend geborenen. De toepassing van de ACS kan uitgebreid worden naar andere vormen van zorg rondom de geboorte zoals zuigelingenzorg, postnatale zorg en postabortuszorg.

Curriculum Vitae

Hasifah Kasujja Namatovu was born on 30th November 1983 in Rome, Italy. She obtained a Master of Science in Information Systems from Makerere University in Uganda in 2011. In 2006, she graduated with a Bachelors' degree in Business Computing with honors from Makerere University. She attended primary education at Kampala Primary School and went to Mbogo High School and Kawempe Muslim Secondary School for ordinary and advanced levels.

Hasifah worked with Uganda Telecom as an internet and data advisor, acted as dean for two years at International University of East Africa. She also offered part time teaching services at Islamic University in Uganda, Uganda Management Institute, Makerere University Business School, Ndejje University and Uganda Technology and Management University. Hasifah is currently a full-time lecturer in the department of Information Systems at Makerere University, College of Computing and Information Sciences.